Subject Index to Volume 4

A

Ankylosis, tooth eruption and, 4:5:39
Antibacterial agent, topical fluorides as, 4:1:21
Arch length, 4:5:31
Automatic film processing, 4:6:18

B

Baseline gingivitis scores, reduction with repeated prophylaxes, 4:6:28

C

Cancer, head and neck, early detection using oral/facial self-examination, 4:5:47
Caries Prevention, by electroless deposition of metals, 4:1:37
Child behavior problems, prevention in the dental office, 4:2:23

D

Dental Film Processor, automatic, care and maintenance of, 4:6:20
Dental plaque, effect of urea peroxide solution on, 4:6:25
Dental practice, topical fluorides in, 4:4:25
Dental radiography, factors that influence quality, 4:6:8
Dental radiography, with the versatile intraoral positioner system, 4:3:14
Dental radiology, rare earth imaging in, 4:3:7

F

Fluoride, enamel, its anti-caries effects, 4:1:8
Fluoride rinsing, 4:5:25
Fluorides, topical, as an antibacterial agent, 4:1:21
in dental practice, 4:4:25
Fluoride supplements, for infants and preschool children, 4:3:28

G

Gingival health, psychological and chemical mediators of, 4:4:6

H

Health, gingival, psychological and chemical mediators of, 4:4:6

L

Lesions, proximal surface carious, histologic-radiographic relation of, 4:6:23

M

Malignant disease, role of dentistry in treatment, 4:1:28
Mediators, psychological and chemical, of gingival health, 4:4:6
Microleakage, prevention, and achievement of optimal marginal adaptation, 4:2:16

O

Orthodontics, preventive and interceptive, 4:5:7

P

Papillary bleeding index, patient motivation with, 4:4:20
Patient motivation, with the papillary bleeding index, 4:4:20
Prophylaxis, repeated, reduction of baseline gingivitis scores with, 4:6:28

R

Rare earth imaging, in dental radiology, 4:3:7

S

Self-examination, oral/facial, early detection of head and neck cancer using, 4:5:47
Sugar-substitutes, in preventive cariology, 4:2:8
Swine flu program, related to preventive dentistry, 4:6:37

T

Tooth eruption, and ankylosis, 4:5:39

U

Urea peroxide solution, effect on dental plaque, 4:6:25

V

Versatile intraoral positioner system, dental radiography with, 4:3:14

Authors Index to Volume 4

B

Braham, R.L., 4:1:28
Buchholz, R.E., 4:6:23

C

Chilton, N.W., 4:6:28
Crabtree, C. L., 4:6:8
Cutright, D.E., 4:1:37

E

Eichenbaum, I.W., 4:5:39
Elsasser, Ch., 4:4:20

F

Fortier, A.P., 4:6:20
Freeman, J.D., 4:5:7
Freedman, M.L., 4:3:7

G

Grabau, J.C., 4:5:47

H

Hoffman, J.I., 4:1:37
Hummel, E., 4:3:7

I

Imfeld, Th., 4:2:8

K

Kirchhof, S., 4:3:7
Korf, S.R., 4:2:23

L

Leske, G.S., 4:5:25
Loesche, W.J., 4:1:21
Lowey, W.G., 4:5:25
Lüescher, B., 4:2:16

M

Malerman, A.J., 4:5:31
Mandel, I.D., 4:6:28
McDermott, T., 4:2:16
Mellberg, J.R., 4:1:8
Manhold, E.A., 4:6:25
Manhold, J. H., 4:6:25
Mühlemann, H.R., 4:2:6,8,16,4:5,6

O

O'Keefe, T.J., 4:1:37

P

Parkins, F.M., 4:1:5, 4:3:28, 4:6:30

R

Reiskin, A.B., 4:3:7
Richards, A.G., 4:3:6
Ripa, L.W., 4:5:25

S

Saxer, U.P., 4:4:20
Scott, S.J., 4:5:47

T

Talbott, K., 4:6:28
Thunthy, K.H., 4:6:18
Turconi, B., 4:4:20

U

Updegrave, W.J., 4:3:14

W

Waldman, H.B., 4:6:37
Wefel, J.S., 4:3:28, 4:25
Wei, S.H. 4:3:28, 4:25
Woody, R.D., 4:1:37

FLUORIDE SYMPOSIUM
Beginning in This Issue

Vol. 4 • No. 1
January - February 1977
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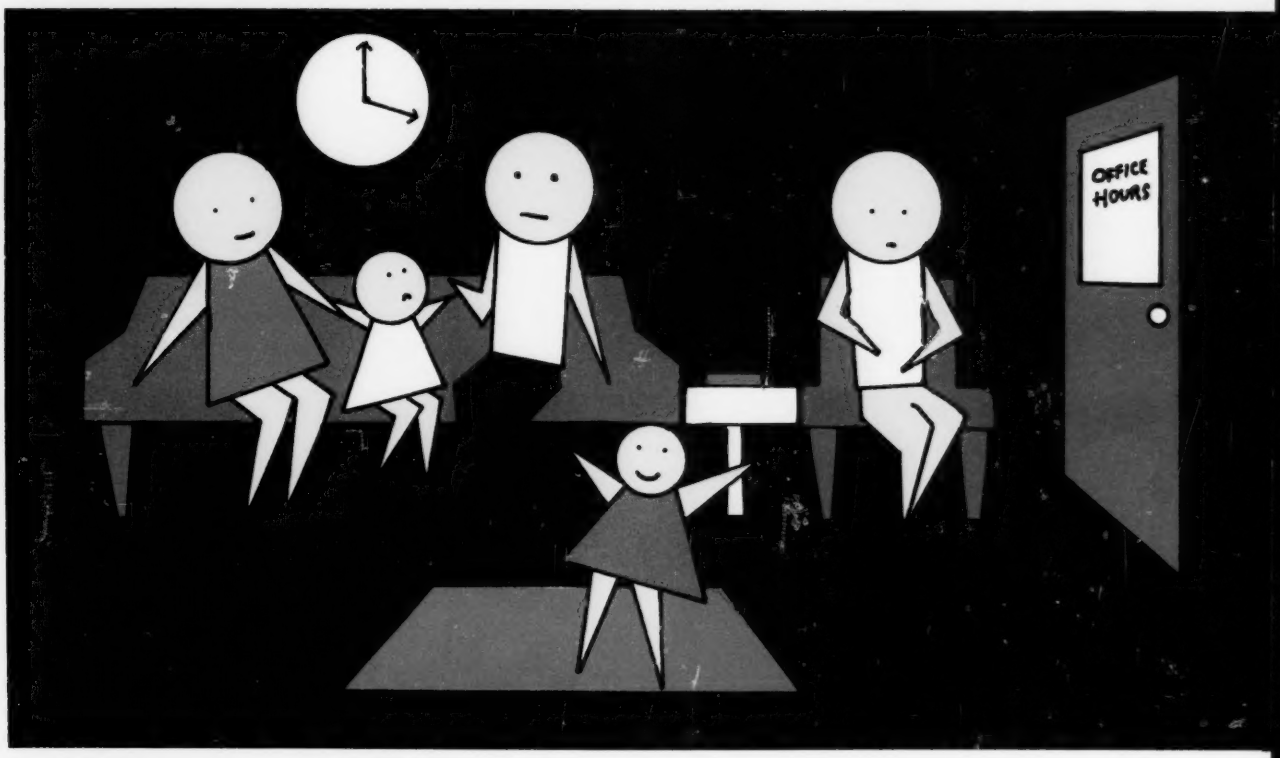

Fluorides in Preventive Dentistry. See Page 5

With this issue we feature symposia developed by guest editors on selected topics in the field of preventive dentistry. Papers from various symposia will run concurrently in succeeding issues along with articles of broad interest. Dr. Frederick M. Parkins is guest editor of the symposium on fluorides beginning in this issue.

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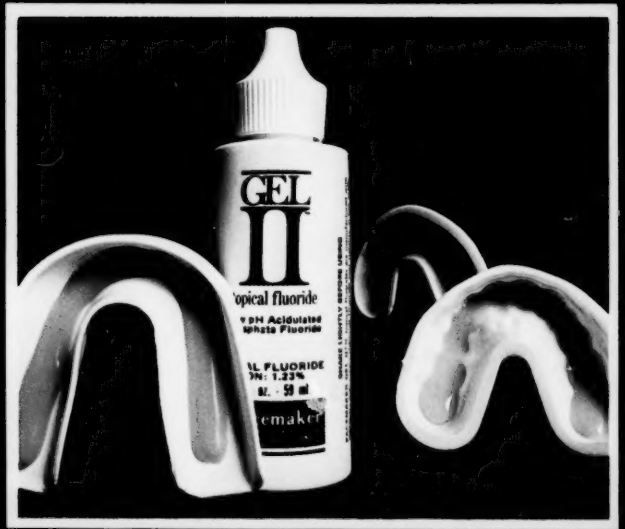

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THE JOURNAL OF

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Vol. 4 • No. 1 January-February 1977

contents

SYMPOSIUM ON FLUORIDES	**5**	Preface Frederick M. Parkins, D.D.S., M.S.D., Ph.D.
	8	Enamel Fluoride and Its Anti-caries Effects James R. Mellberg
	21	Topical Fluorides as an Antibacterial Agent Walter J. Loesche
RESTORATIVE DENTISTRY	**28**	The Role of Dentistry in the Treatment of Malignant Disease Raymond L. Braham, B.D.S., M.Sc.D.
CARIES PREVENTION	**37**	Caries Prevention by Electroless Deposition of Metals *A Preliminary Primate Study* D. E. Cutright, D.D.S., Ph.D., R. D. Woody, D.D.S., T. J. O'Keefe, Ph.D. and J. I. Hoffman, B.S., M.P.H., D.D.S.

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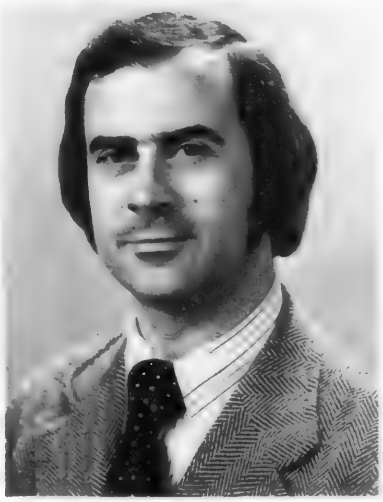
Preface

Frederick M. Parkins, D.D.S., M.S.D., Ph.D.*

Fluoride benefits have been primarily provided through water supplies to entire communities through the efforts of politicians and the officials of public works in consultation with dental organizations. Direct professional management of individualized treatment with fluoride is a recent trend. Research has provided new knowledge about fluoride action and about the process of dental caries. These findings now make it possible to use fluoride as chemotherapeutic agent.

The papers to be published in this and future issues of the *Journal of Preventive Dentistry*, were selected to acquaint the practicing dentist with the latest concepts of how fluoride works and how fluoride preparations can be used to help individual patients. The action of fluoride in the prevention of caries is featured in two separate presentations. The incorporation of fluoride into enamel and its direct effects on enamel undergoing carious attack is covered by James Mellberg. The alterations of cariogenic microorganisms by fluoride which is now being recognized as an important aspect of fluoride action, is reviewed by Walter Loesche along with his proposal for treatment.

Significant reductions in the occurrence of dental caries have been observed with two different types of fluoride therapy. Applications of higher fluoride concentrations to enamel surfaces at annual or semiannual intervals have proven effective with residents of both fluoride deficient and optimally fluoridated communities. Various types of treatments with high potency fluoride preparations will be discussed by Stephen Wei and James Wefel, and their recommendations for professional use of these products are presented. I assumed responsibility for describing the benefits and administration methods appropriate to lower potency fluoride preparations which are used on a daily to weekly frequency. The variety of tablets, rinses, drops and dentifrices can be confusing. Explanations and recommendations for each are discussed.



Frederick M. Parkins, D.D.S., M.S.D., Ph.D.

The growing use of fluorides by physicians in the treatment of bone diseases will be in a future issue discussed by Herta Spencer. The larger quantities of fluoride ingested daily for extended periods have provided new fluoride research opportunities and demonstrated the safety of fluoride treatment of all types. Dentists familiar with this use of fluoride should be able to discuss fluoride therapy more easily with patients.

Not described in this issue because of space limitations and the as yet scattered evidence is the additive effect of combining high potency-low frequency fluoride treatments with low potency-high frequency treatments. It appears that the mechanisms of action for the two types of treatments are separate enough for each to be effective simultaneously. Three examples may help to illustrate the point. Ringelberg *et al.*[7,8] observed separately the benefits of the weekly use of a 0.2 per cent sodium fluoride mouthrinse and the twice yearly use of a 2.2 per cent phosphate fluoride

* Associate Dean for Academic Affairs, College of Dentistry, The University of Iowa, Iowa City, Iowa 52242.

self-applied prophylactic paste. On a similar population they evaluated the benefits of the combined use of both methods and found significantly greater caries prevention than with either method alone. Scola[9] reported additive benefits from the combined use of a self-applied 9 per cent stannous fluoride prophylactic paste followed by a 10 per cent stannous fluoride application semiannually with the daily use of a 0.4 per cent stannous fluoride dentifrice. Englander *et al.*[2,3] combined both high potency and high frequency into a single agent method. Gels containing 0.6 per cent sodium fluoride were applied daily in custom fitted mouth trays. Their results show reductions in the incidence of dental caries, enamel uptake of fluoride and continued post-treatment effects which are greater than have been observed with other single agent methods of fluoride treatment which are typical of either low potency-high frequency or high potency-low frequency. All three examples illustrate the potential for patient benefits and future research.

Because of its timely emphasis the use of fluoride with infants has been developed in a brief and separate paper. Recent literature reflects a more cautious approach to fluoride daily dosages for children below two years of age. Reports of mild mottling of enamel on permanent incisors of patients receiving the previously recommended 0.5 mg sodium fluoride since birth[1,4–6] have led to a reassessment of the daily quantity suggested for this age range. Physicians prescribing 0.5 mg sodium fluoride and vitamin combinations should be especially appraised of these new findings and recommendations. Clinical reports are now being received personally describing mottling even on the teeth of physicians' children. In a manner analogous, though less serious, the situation resembles the recognition of tetracycline staining.

It is hoped that this issue will contain much useful information. The contributors have expended considerable effort to provide the latest findings and recommendations. To each of the other participants who made this issue possible, I extend my deepest appreciation.

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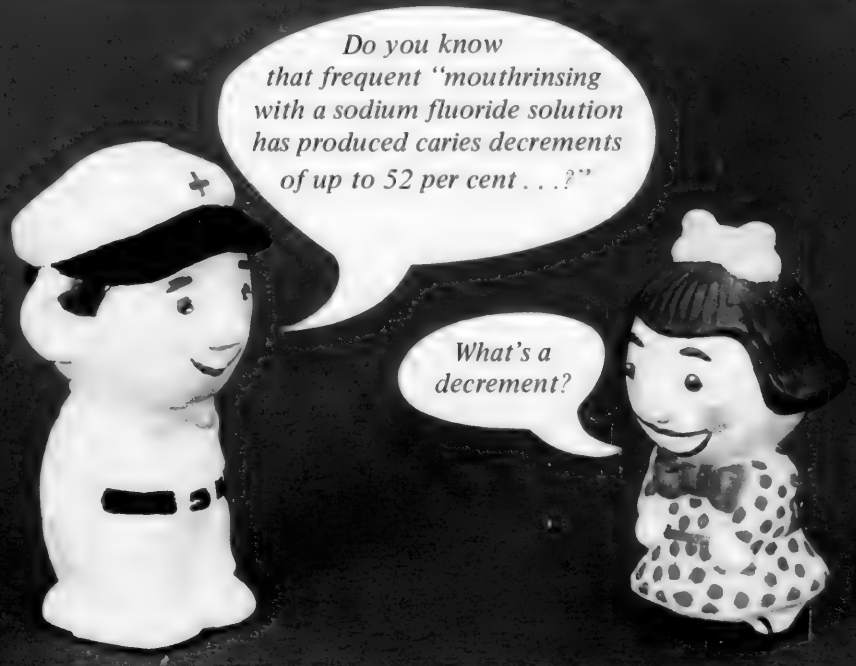
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*Helfetz, S. B., Horowitz, H. S., Driscoll, W.S. Feb., 1974. *Journal of the Canadian Dental Association* 40: 136-46.
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Enamel Fluoride and Its Anti-caries Effects

James R. Mellberg*

There has been interest in enamel fluoride concentrations ever since the early epidemiological studies of Dean[14] on the relationship of fluoridated drinking water to caries prevalence and those of Bibby[9] and Knutson[37] showing that topical applications of fluoride inhibit caries formation. It is now a well known and widely accepted fact that fluoride inhibits caries. The manner in which fluoride accomplishes this and the optimization of its use is less well understood. The implication that higher fluoride levels in enamel are directly related to lower caries scores appeared early to be borne out not only by epidemiological studies but also by the results of clinical trials showing that topical agents that deposited more fluoride in enamel in laboratory experiments tended to result in greater caries inhibition. More recent findings, however, have shown that a direct or simple correlation of enamel fluoride to caries inhibition is insufficient to explain all clinical findings. It has become quite clear that there is more than one mechanism by which fluoride inhibits caries and that several may function simultaneously. Furthermore, the degree to which each mechanism functions is likely to differ depending upon the frequency and concentration of the fluoride applications. Broadly grouped, the mechanisms given major attention are: 1) increased enamel resistance (presumably from high fluoride levels); 2) remineralization of porous enamel; and 3) anti-bacterial effects.

It is the intention of this paper to consider the effects of fluoride in sound and porous enamel on caries resistance. This is difficult to present simply and clearly because enamel fluoride effects must be separated from other possible anti-caries effects of fluoride where, in many cases, the other effects may dominate. For example, anti-bacterial and remineralization effects may dominate when fluoride is applied frequently as with daily mouthrinses. Nevertheless, the following discussion will first describe the amounts and distribution of fluoride deposited in enamel during its formation and during periods of local contact with fluoride after the tooth erupts. Next, evidence currently available will be presented showing how fluoride probably functions in different ways to prevent or inhibit the progression of caries under different circumstances.

* Colgate-Palmolive Research Center, 909 River Road, Piscataway, New Jersey 08854.

Systemically Acquired Fluoride

Fluoride is acquired by natural means at several times during the life time of the tooth. During its very early formative period, fluoride concentrations may be relatively high but as the tooth matures and begins to mineralize, the concentrations fall.[74] There then follows a period of mineral deposition frequently referred to as pre-eruptive maturation, when the enamel becomes more completely mineralized. It is during this period that most of the enamel fluoride is acquired[11] with the amount depending on the concentrations of fluoride in food, water or fluoride supplements ingested by the subject as well as on the duration of the pre-eruptive maturation phase of the enamel. Deciduous teeth have a shorter period of enamel mineralization than permanent teeth and consequently a lower fluoride concentration. Small differences in fluoride concentrations between different types of permanent teeth also have been attributed to differences in the length of the pre-eruptive maturation phase.[6]

As the unerupted enamel becomes more fully mineralized, fluoride is less able to penetrate and fluoride deposition becomes increasingly restricted to the surface. As a result, the surface acquires much higher concentrations than the interior. Although enamel may total 1000 μm thick (1 mm) high fluoride concentrations are normally found only in the outer 30–50 μm. Figure 1 shows typical fluoride concentrations acquired systemically by permanent and deciduous teeth from fluoridated and non-fluoridated water areas. Concentrations of fluoride measured nearer the outer surface than shown in Figure 1 are even higher. For example, permanent enamel sampled to a depth of 2 μm was found to contain an average of approximately 1700 ppm F in a non-fluoridated area (<0.1 ppm F), 2200–3200 ppm F in several optimally fluoridated areas (1.0 ppm F) and over 4800 ppm F in an area with 5–7 ppm F in its water

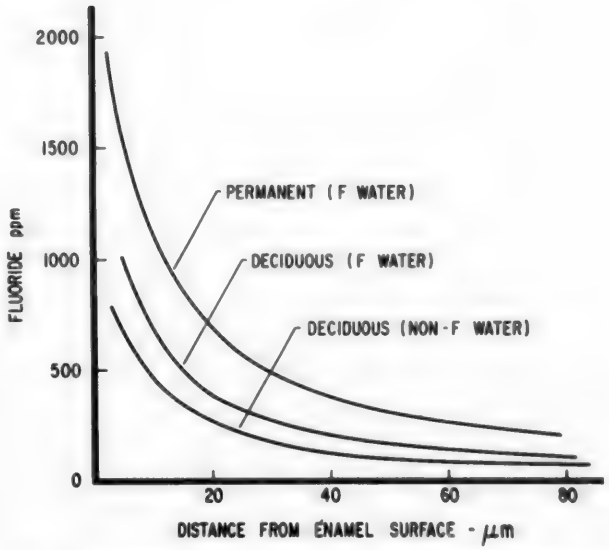

Fig. 1. Fluoride concentrations in human enamel according to depth.

supply.[1] The outer 1–2 μm enamel from permanent teeth of children who consumed fluoride tablets from shortly after birth, contained 3060 ppm F compared to 2320 ppm F in children who drank fluoridated water and 1870 ppm F in children who drank non-fluoridated water.[7]

Within a single water fluoride area there is great variation in enamel fluoride concentrations between different teeth. Teeth from a non-fluoridated area may even contain more fluoride than teeth from a fluoridated area (Fig. 2). The concentration of fluoride from area to area over the surface of a tooth also is not constant. Newly erupted teeth have been shown to contain more fluoride near the incisal edge,[76] possibly because the incisal enamel has a longer pre-eruptive stage. However, as the teeth age, wear removes some of the outer enamel and the fluoride decreases until it eventually may reach the low levels of subsurface enamel. Fluoride lost by abrasion or attrition is not replaced by contact with fluoride in food or drinking water.[2,75] However, fluoride concentrations will increase at sites attacked by acids, for example, under plaque or otherwise made more porous.[45]

Topically Acquired Fluoride

In this paper, the term "topically acquired" refers to the acquisition of fluoride by erupted enamel from all forms of treatment. This includes fluoride from mouthrinses, tablets and pastes as well as annual gel applications.

There are many factors that determine the amount of fluoride acquired from topical exposure. These will not all be discussed here but include the age of the tooth and its original fluoride concentration. Older teeth and those with higher fluoride concentrations take up less fluoride.[52,65] Variables in the treatment preparation affect acquisition; higher fluoride concentrations, higher temperature and lower pH result in greater deposition.[50] These factors also may affect the type of reaction products formed with the enamel which are related to the permanence of the enamel fluoride and possibly also its anti-caries properties.

The bioavailability of fluoride in the treatment preparation, that is, its ability to get to the site of anti-caries action, is another variable that must be kept in mind. It is not valid to assume an equal effect on enamel from two preparations having the same fluoride concentration, pH, etc., but having different bioavailability. This can arise when substances in the preparation inactivate fluoride as was the case in early forms of fluoride dentifrices and prophylaxis pastes or from thickeners or other substances that interfere with the ability of the fluoride ion to react with enamel.[20,51]

A determination of the amount of fluoride deposited in enamel under real *in vivo* conditions has been done by analyzing deciduous teeth exfoliated during the course of clinical trials. Because the analytical methodology was standardized,[66] the results from a number of studies of different fluoride treatment forms can directly be compared. The response of permanent and deciduous teeth to topical fluoride agents appears

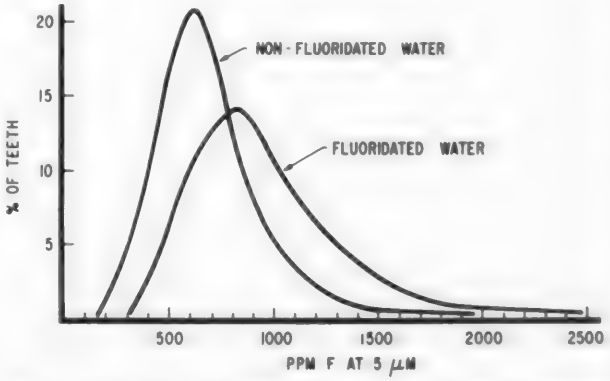

Fig. 2. Frequency distribution of deciduous teeth containing various amounts of fluoride at 5 μm depth.

Table 1. The Increase in Enamel Fluoride Concentrations of Deciduous Teeth Exposed to Various Fluoride Preparations.

Preparation	F Conc. (%)	pH	Applications No. and Frequency		PPM F Increase at 5 μm Depth	Ref.
Solution						
APF	1.2	3.2	1		190*	28
SnF_2	2.4	2.3	1		30*	28
Gel self-applied						
APF	1.2	3.2	10	4/yr	1100	59
APF	1.2	3.2	5	5/wk	700†	55
APF	1.2	3.2	10	5/wk	1000†	55
APF	1.2	3.2	25	5/wk	1600†	55
APF	0.5	4.5	200	5/wk	2300	49
APF	0.5	4.5	200	3/wk	1400†	58
APF	0.5	7.0	200	5/wk	1000	49
Prophylaxis paste						
Self-applied APF	0.4	3.2	6	4/yr	200	59
Self-applied APF	0.4	3.2	1–9	2/yr	100‡	61
Prof.-applied APF	0.4	3.2	4	2/yr	275	17
Prof.-applied APF	0.4	3.2	1		90*	28
Prof.-applied SnF_2	2.2	3.0	1		0*	28
Mouthrinses						
NaF	0.02	7.0	194	5/wk	21	53
NaF	0.30	7.0	12	1/wk	24	54
APF	0.02	4.0	190	5/wk	82	53
APF	0.02	4.0	142	5/wk	91	60
APF	0.10	4.0	30	1/wk	334	60
APF	0.30	4.0	12	1/wk	572	54
Tablets						
NaF	1.0 mg	7.0	3/yrs school days		130	57

* Adults, permanent teeth.
† Fluoridated water areas.
‡ Anterior teeth, most lost within 6 months.

to be roughly similar[65] with the possible exception that penetration might be less[58] in permanent teeth.

Table 1 lists results from a number of clinical studies where a variety of treatment forms were used. Not all possible treatment preparations and conditions are represented in the table but there is sufficient information to provide an overall view of the degree of enamel fluoride uptake *in vivo* from commonly used preparations. It is very apparent from the table that repeated applications of acid preparations increase enamel fluoride concentrations to very high levels whereas frequent applications of neutral (pH 7) or very dilute acid preparations do not.

By studying the amount of fluoride deposited *vs* the number of applications of a specific treatment preparation it can be shown that less fluoride is deposited in sound enamel per application as the number of applications increase. This decrease in uptake occurs sooner with preparations that normally deposit smaller amounts of fluoride in enamel. Thus, fluoride levels in enamel treated with neutral pH mouthrinses appear to reach a maximum within several weeks or less after use of the rinses whereas it takes several years or more with self-applied acidulated-phosphate-fluoride (APF) gels.

It should be noted that the increase in enamel fluoride discussed above and shown in the table refers to sound enamel; fluoride uptake by etched or porous enamel is likely to be proportionately much greater. Unfortunately, fluoride deposition in etched or porous enamel from various fluoride treatments has not similarly been determined.

Because in most cases the acquisition of fluoride by the teeth shown in the table took place over a period of months or years the values reflect permanently bound fluoride. However, much of the fluoride initially taken up by enamel is only adsorbed or in the form of soluble compounds and soon is lost. The period of loss is determined

(continued on page 12)

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by the amounts of loosely bound fluoride present but can be as rapid as one or two days from single topical applications or mouthrinses[4] to as long as 8 months after a series of 25 daily APF gel applications.[55] The fluoride remaining in the teeth after this period appears to be permanently bound.

Penetration of fluoride from topical exposure usually is not great. Fluoride from a single application of APF gel will penetrate to approximately 30 μm and to 5–15 μm after repeated use of a fluoride mouthrinse. Much greater penetration, however, is attained from repeated use of APF gels. After 200 applications of APF gel (0.5% F, pH 4.5) fluoride levels of 300 ppm F or more have been found 250 μm below the surface of deciduous teeth.[49]

Attempts have been made to increase the amount of fluoride deposited in enamel from topical agents. In addition to the APF system, other approaches have included pre-treating with acid[3] or metal ions[46] and the application of a barrier[56] or sealant to the treated surface to trap the fluoride and give it a longer time to react. Although all of these approaches increased enamel fluoride none of them have been tested sufficiently to determine if they are a significant improvement over currently used procedures.

Relationship of Enamel Fluoride to Caries Inhibition

The amount of caries protection a tooth will receive from fluoride is determined in broad terms by the balance between caries challenge and enamel resistance. If the challenge (sucrose consumption, cariogenic bacteria, deep fissures, *etc.*) is low, a relatively small amount of resistance conferred by fluoride may give the same degree of protection as much greater resistance when the challenge is great. When the challenge is very great, no amount of fluoride exposure may be able to overcome its destructive effects. Therefore, it is likely that there is no specific level of fluoride in enamel or frequency of exposure that can be expected to totally prevent caries under all conditions or even inhibit its formation by a particular per cent.

When discussing the effects of enamel fluoride on the resistance of teeth to caries, two types of enamel should be considered: sound enamel and hypomineralized or porous enamel. Although fluoride is present in both types and additional amounts can be deposited, its mechanism of action, that is, its effect on caries resistance or progression of the lesion is probably different for each type.

Sound Enamel. It has been shown that enamel formed in the presence of fluoride has more perfect crystals,[24] is less soluble in acid[34] and is less prone to develop caries.[14] When the levels of surface fluoride in enamel from areas with fluoridated and non-fluoridated drinking water are compared to caries prevalance a clear correlation is found.[13,16,35] The correlation is not statistically significant, however, when made within a single community[12,16,25] although DePaola *et al.*[16] stated that 16 per cent of the caries variation could be attributed to enamel fluoride. Nevertheless a positive correlation of high natural enamel fluoride to caries resistance is suggested by the caries history of subjects whose teeth were formed under the influence of fluoridated water but later moved to non-fluoridated areas. Deatherage[15] found that subjects who moved from fluoridated water areas maintained some protection for as long as 20 years. Two other studies[67,73] reported residual protection lasting at least several years.

The value of high levels of fluoride in sound enamel is also supported by the residual caries protective benefits of topical applications. A few clinical trials have been conducted where clinical examinations were continued for two or more years after the fluoride applications were concluded. In those trials where it was shown, or could be presumed, that deposition of fluoride in sound enamel was relatively high, significant residual anti-caries effects were found. These included daily self-applications of APF or neutral NaF gels (0.5% F) self-applied in mouthpieces[18] and professional applications of APF (1.2% F)[31] or SnF_2 solution (1.0%).[32]

In contrast to the above studies, residual benefits were less clear where fluoride deposition in sound enamel would be expected to be low. Four early studies of short series of neutral NaF applications showed residual benefits in two of them[10,38] but not in the other two.[69,70] In more recent studies, a residual benefit was found after use of 0.1 per cent NaF dentifrice for three years[40] but not from fortnightly use of 0.1 per cent F mouthrinse.[39]

Fluoride in animal teeth has also shown residual anti-caries effects. In a study designed to differentiate between the different fluoride protec-

tive mechanisms it was shown that caries formation in the rat could be inhibited by about 50 per cent if the fluoride levels in the enamel were increased to 2500 ppm before instituting the cariogenic challenge.[42] Lower enamel fluoride levels were proportionately less effective. A partial residual effect was also shown in hamsters.[19]

As discussed earlier, high fluoride concentrations normally exist only in the outer 30–50 μm of enamel. Topical applications, unless of relatively high potency (*e.g.* APF with 0.5% F) and given frequently,[49] do not significantly increase fluoride levels below this depth. Yet it is below this depth that mineral loss of a lesion is first observed. Therefore, it should not be too surprising that an inverse correlation between caries and surface enamel fluoride is difficult to demonstrate. This is not to imply that fluoride in surface enamel does not provide increased resistance to caries, for it has been shown that the relatively sound outer layer of enamel over the beginning lesion is thicker when fluoride concentrations are high.[71] Nevertheless, correlations of fluoride concentrations in deep enamel (*e.g.* 50 μm) with caries have never been attempted. Although natural differences at this depth may not be great enough to show a large fluoride effect, increasing them for example by repeated applications of a potent fluoride solution, without increasing porosity or otherwise adversely effecting the enamel, could be expected to improve caries resistance.

Hypomineralized Enamel. Several clinical studies have been conducted where it was shown that fluoride deposition in sound enamel differed significantly between two test preparations yet caries inhibition scores were similar.[5,18,26] The implication that fluoride deposition has *no* effect on caries inhibition need not be correct since the studies all had in common the fact that only sound enamel fluoride was measured and the test preparations were administered frequently (daily or weekly). It could be postulated that the caries inhibiting effect of frequent exposure of plaque, hypomineralized enamel and early caries to fluoride was greater than the additional resistance conferred to the sound enamel by acquired fluoride. This is supported by a study with rats which showed that high concentrations of fluoride in sound enamel suppressed caries formation, but that daily exposure to low levels of fluoride in the drinking water (that did not increase enamel fluoride) was much more effective.[42] These findings suggest that a very important anti-caries mechanism of fluoride may be related to freely available fluoride ions not necessarily at high concentrations. It is likely that this activity is related to the ability of traces of fluoride to cause precipitation of hydroxyapatite from supersaturated solutions or to the ability of porous enamel to accumulate fluoride more readily than sound enamel.

There are two types of hypomineralized enamel that fluoride might affect: developmental and acid demineralized. Developmental hypomineralized enamel refers to specific areas of enamel as it erupts into the mouth. Although the entire enamel surface is less than fully mineralized upon eruption and therefore will acquire somewhat larger amounts of fluoride from topical exposure, certain areas contain even lower amounts of mineral. These may be indicated by small, opaque white areas of greater caries susceptibility.[8] The presence of hypomineralized enamel areas in rats has been well documented,[22,23] as well as the increased rate of their disappearance brought about by the enhancement of hydroxyapatite precipitation from salivary calcium and phosphate. Thus, an important mechanism of fluoride action appears to be an increased rate of enamel maturation. This is further supported by the findings that topical effects of fluoridated drinking water[8,27,36] or fluoride applications[5,17,30] are greater on newly erupted teeth than on teeth erupted earlier. Backer-Dirks[8] determined the topical effect of water fluoridation on the distal surface of previously erupted first molars and found that the benefit ranged from 30 per cent fewer cavities when fluoridation began shortly after eruption to no benefit approximately 6 years later.

Demineralized enamel can result from several causes, but acidogenic plaque is the cause related to dental caries. Because acid is formed intermittantly by plaque, the pH of the solution in contact with the tooth fluctuates from above 7 to below 5. When the pH is below about 5.5[47] enamel dissolves but if no additional acid is supplied the pH will rise and dissolved mineral not leached out of the lesion will reprecipitate. In the absence of fluoride the compounds precipitated may be more soluble in acid than the original enamel so that during the next acid attack they are more readily dissolved. In the presence of fluoride, hydroxy-

apatite forms[47] which is similar in solubility to enamel. Furthermore, the precipitated hydroxyapatite will contain fluoride, probably in the form of fluoroapatite which will require a slightly lower pH to dissolve and when it does will provide fluoride ions to again enhance reprecipitation.

When the calcium and phosphate precipitated in the developing lesion originate from outside the tooth, the process is referred to as remineralization and the natural remineralizing solution is saliva.[41] The remineralizing effects of saliva can be improved by fluoride as shown by *in vitro*[21] and *in vivo*[72] experiments. Von der Fehr[72] developed white spot caries in students by eliminating oral hygiene and using frequent sucrose rinses. The white spots were subsequently remineralized by resuming oral hygiene and substituting fluoride rinses for the sucrose rinses. Artificial remineralizing solutions containing fluoride have been developed which have shown some promise[44,48] but need additional testing before they can be recommended. Other evidence related to remineralizing effects of fluoride are the findings of a fluoride rich zone in carious lesions,[43] the accumulation of fluoride in enamel defects[45] and the increase in enamel fluoride near the gingival margin where plaque is usually found.[76] Also, several investigators have reported the arrest or slowing of the formation of carious lesions after topical fluoride applications.[29,33,62,63,64] Although a visible lesion may become arrested, complete remineralization is not likely unless the enamel has a relatively intact outer surface.

To promote remineralization most effectively, fluoride should be present during the time of acid attack or when conditions are favorable for the slow growth of crystals from salivary ions. This is favored by the continuous presence of fluoride in the microenvironment of the lesion or at least by very frequent exposure. Because hypomineralized enamel is able to accumulate fluoride more readily than sound enamel, it not only will become less soluble but may develop a "reservoir" of fluoride that will be released during the acid attack. If the exposure to topical fluoride is great enough, the reservoir may be in the form of CaF_2 or other fluroide compounds, which will slowly dissolve to provide fluoride for the enhancement of remineralization. The amount of fluoride in the "reservoir" will probably depend not only on the frequency of the caries attack but also on the frequency and concentration of fluoride exposure and the thickness of the overlying plaque. After treatment with high fluoride concentrations, resulting in a large "reservoir," it is conceivable that released fluoride could produce a bacteria suppressing feed-back effect that would shorten the attack or moderate the pH drop produced.

SUMMARY

Fluoride in sound enamel exists primarily in the outer 50 μm and mostly results from systemic exposure. It varies greatly in concentration both within and between populations but can be increased by varying amounts with topical applications. Multiple applications of relatively high potency preparations are needed to increase fluoride in deep enamel; below about 50 μm. This may theoretically be important since the major demineralization of an early lesion occurs near this depth.

Some fluoride preparations do not increase fluoride significantly in *sound* enamel yet produce inhibition when used frequently. It is likely that this is the result of the enhancement of mineral deposition and fluoride deposition in hypomineralized enamel including early lesions.

Because both high levels of fluoride in sound enamel and frequent application of fluoride are factors that appear to be important in determining the degree of caries inhibition, the best anticaries effect might be obtained from a combination of infrequently used high potency fluoride and frequently used low fluoride preparations.

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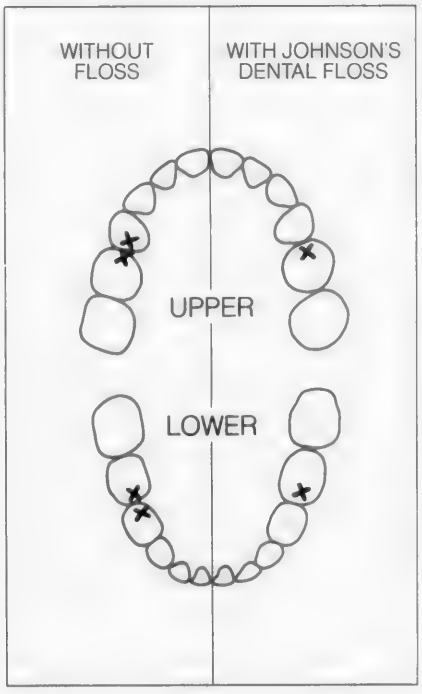
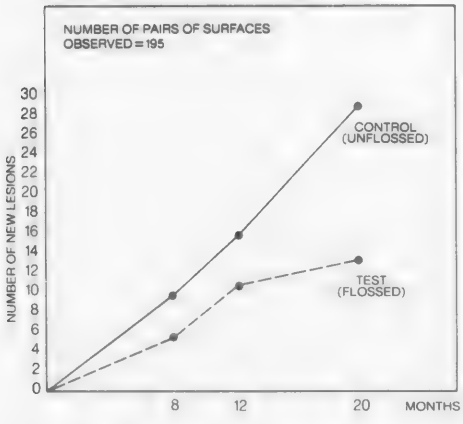


NUMBER OF TEST AND CONTROL SURFACE FAILURES IN 44 CHILDREN FOLLOWED FOR 20 MONTHS*



*Flossing was omitted during months 9-12.

For years dental authorities have believed that flossed surfaces are far less likely to develop caries than unflossed surfaces. Now this opinion has been confirmed—quantitatively—in a recent clinical study on schoolchildren.[1]

In this trial, 44 first-graders were monitored for 20 months to compare the failure rates of caries-free unflossed control surfaces and their flossed contralateral counterparts. Regular flossing was performed by trained research assistants using a standardized technique.

Result: as the graph shows, unflossed surfaces failed at more than twice the rate of surfaces treated with Johnson's Dental Floss—an especially important finding for fluoride-deficient areas such as the one where this study was performed.

a significant bonus—improved gingival health

Over the years, many authorities have attested to the prophylactic value of flossing, not only for caries prevention, but for improved gingival health as well.[2,3,4,5] By dislodging food particles and plaque, flossing improves the general tone of the interdental gingivae...may prevent the progression to periodontal disease.

You know the value of daily flossing. Your patients may not. That's why your recommendation for daily use of Johnson's Dental Floss is still the surest way to put better dental hygiene at their fingertips.

Help your patients find out for themselves, by using the attached postage-free reply form to order a supply of Johnson's Dental Floss in trial-size dispensers.

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(continued from page 16)

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Topical Fluorides as an Antibacterial Agent

Walter J. Loesche*

The impressive ability of water fluoridation to reduce caries is attributed to changes in the physical and chemical properties of enamel brought about by the incorporation of fluoride ions into apatite crystals during the period of tooth formation.[7,18] Topical fluorides also reduce caries prevalence[11,21] but the efficacy of these preparations does not seem to be dependent upon their ability to incorporate fluoride into the enamel crystals.[1,7] This raises the possibility that topical fluorides have another mechanism of action in addition to the well documented effect of fluoride on enamel solubility. This could be an antibacterial effect on plaque bacteria. *In vitro*, small amounts of fluoride, *i.e.*, 5 to 10 ppm, will inhibit growth of pure cultures of oral bacteria.[12] The levels of fluoride in the saliva of individuals consuming fluoridated water are below these inhibitory levels, and thus, an antibacterial effect on plaque organisms resulting from water fluoridation has never seemed plausible. However, the levels of fluoride delivered by some topical fluoride preparations, *i.e.*, 500 to 1000 ppm, would be bactericidal. The present essay will consider the argument that topical fluorides act in part by exerting an antimicrobial effect. As with any antimicrobial agent, maximal benefits can be achieved only if the agent is properly given. This requires an understanding of the role that bacteria play in dental decay. Decay may be due to acid production by any or all plaque bacteria, or due to the proliferation and dominance in plaque of certain acidogenic organisms such as *S. mutans* and lactobacilli. The former possibility will be identified as the nonspecific plaque hypothesis (NSPH) since the identity of the bacteria is immaterial to the treatment approach. The latter possibility will be called the specific plaque hypothesis (SPH), as the identification of the bacteria is essential to the treatment. These hypotheses require different treatment schedules and predict different outcomes.[15] Each will be examined in the light of existing experimental results, but first we should discuss the mechanisms by which fluoride inhibits bacteria.

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MECHANISM OF FLUORIDE'S ANTIBACTERIAL ACTION

Bactericidal Action. In vitro, fluoride will inhibit many enzymes essential to cell metabolism and growth.[12] The inhibitory concentration is dependent upon the enzyme studied and will vary from 0.2 ppm to 190 ppm. We will consider the effect on enolase, an enzyme involved in carbohydrate metabolism. If enolase is inhibited, phosphoenol pyruvate (PEP) is not formed and the cell is unable to derive energy via the glycolytic pathway. PEP is also involved in the uptake of glucose into many plaque bacteria, including the streptococci.[20] Thus the inhibition of enolase would effectively eliminate the carbohydrate fermenters from plaque by preventing the assimilation of glucose into the cell and by preventing the fermentation of other carbohydrates via the glycolytic pathway. This antibacterial action of fluoride is nonspecific as all enolase-containing bacteria would be susceptible.

Antiplaque Action. Fluoride may affect bacterial plaque by mechanisms other than a direct enzyme inhibition. Glantz[10] has suggested from *in vitro* studies that fluoride could lower the surface energy of the tooth surfaces, thereby making bacterial attachment and plaque formation difficult. Many oral bacteria would not adhere to the fluoride treated tooth surface, and if they did, the weight resulting from their proliferation would cause the microcolony to break loose from the tooth surface. The cohesive forces holding the bacteria together would be greater than the ad-

hesive forces holding the bacteria to the tooth. In other *in vitro* studies, fluoride was shown to desorb or strip off bacteria from hydroxyapatite because the fluoride was able to bind more effectively than the bacteria to positively charged areas on the apatite crystal.[19] Both of these observations indicate that fluoride can exert an antiplaque effect without necessarily killing the bacteria. This effect of fluoride would be nonspecific in that the ability of all oral organisms to adhere to the tooth would be reduced. However, as the streptococci are normally the initial colonies of plaque, they would be preferentially discriminated against by this mode of fluoride action.

TREATMENT PHILOSOPHY

From the preceding it is apparent that fluoride is a multipotential antibacterial and antiplaque agent. Yet its usage as such is limited or unheard of in clinical dentistry. This discrepancy may be attributed to our views concerning the etiology of dental decay. Since Miller's time, the opinion exists that decay results from decalcification of tooth substance secondary to acid production in dental plaque. Dental plaque is seen as the pathogen and its reduction or elimination has been a viable treatment goal. This opinion, embodied as the NSPH, is now fixed in our treatment philosophy. It has withstood experimental evidence that in animal models, at least, some forms of dental decay are due to an infection by specific bacteria,[13] *i.e.*, the specific plaque hypothesis (SPH). We shall now examine clinical studies that were performed using antibacterial levels of fluoride under either the NSPH or SPH in order to determine the reasons why they have not influenced the usage of topical fluorides in clinical dentistry.

Treatment Under the NSPH. The basic tenet of the NSPH is that all plaques in all mouths have equal potential to cause dental caries. This implies that no diagnostic criteria for treatment need be used, because no bacteriological differences exist between the plaques present in a clinically healthy mouth and those present in mouths with rampant caries or periodontitis. Thus, in most clinical studies, the subjects are not selected from a population that has decay or periodontal disease, but from one which is most conveniently available. If there is no diagnosis to be made, then some other measurement of the agent's efficacy must be employed. In short term studies the agent's ability to prevent plaque formation in the absence of mechanical debridement procedures such as brushing and flossing is assessed, while in long term studies the agent's ability to decrease the DMF tooth or surface score is measured. Since plaque is continuously forming on the tooth surfaces, the agent must prevent a normal phenomenon. Also, all people form plaque, so all should be treated. Such an open-ended treatment schedule without a foreseeable cutoff point is unprecedented in antimicrobial therapy, unless one includes as a similar treatment schedule the chlorination of drinking water.

The tooth and gingival surfaces are normally colonized by large numbers of bacteria (Fig. 1). When antibacterial levels of fluoride are given, the majority of the plaque bacteria will be killed. The flora will stay suppressed for as long as the fluoride is given. However, when treatment ceases, the plaque bacteria will soon return and present the same cariogenic threat. This is illustrated in Figure 1, where the number of bacteria before and after treatment is essentially the same. Because of this regrowth phenomenon, success under the NSPH requires almost daily treatment. This has provided clinical dentistry with an unusual challenge in regards to the delivery of an effective agent on a universal basis. It has in part been met by water fluoridation, and by fluoride dentifrices. However, for reasons of safety the fluoride in these preparations is below what would be considered as an effective antibacterial level, and the beneficial results achieved can be attributed to other mechanisms of fluoride action. When fluoride is delivered to the tooth surfaces in adequate antibacterial levels under the NSPH, the results have been spectacular.

School children in Cheektowaga, N.Y. were given 0.5 per cent fluoride either as a neutral sodium fluoride (NaF) or acidulated phosphate fluoride (APF) gel each school day during a 21-month period.[7] The gels were added to custom-fitted plastic trays which were then inserted over the teeth and held in place for a 6-minute period under supervision. A neutral pH placebo gel, of identical composition minus the fluoride, served as a control. After 21 months of treatment, the fluoride groups had a 75 to 80 per cent reduction

in new DMFS incremental scores compared to the control group. Significantly more fluoride was incorporated into the tooth surfaces by the APF. This was not associated with a demonstrable clinical difference between the neutral and acidulated fluorides. This tooth-bound fluoride, however, could represent a reservoir of fluoride which after slow release from the tooth, could exert a pharmacological effect on the plaque flora.

The Cheektowaga study has not profoundly influenced subsequent dental therapy, as critics consider the daily gel treatment impractical. The demands of the NSPH have discouraged responsible officials from initiating this type of program. If such a treatment has to be performed on every child, every school day for an unspecified period of years, then more money is needed than any group or agency in the United States is willing at this time to provide. Clearly such extensive prophylactic treatment will occur only when the cost of restorative care is so prohibitive that prevention becomes a viable economic alternative. This situation can be found in several European countries where the caries rate is high and the government is financing treatment. Swedish school children were given a professionally administered dental polishing using a 5 per cent sodium monofluorophosphate (MFP) paste every two weeks during the school year, *i.e.*, 20 times/year.[2,14] Each treatment lasted 10 minutes and involved careful cleaning of approximal and fissure surfaces. After one year the treated group had 0.1 new carious surfaces, whereas, the comparably aged control group had over 3.0 surfaces. This differential has been maintained for two years. Thus for a cumulative total of 3-1/2 hours of treatment time per year, a 95 per cent reduction in new caries has been achieved. The control group also required 3-1/2 hours per year per subject of treatment time, but this was needed for the placement of restorations. In terms of cost benefit, the prophylactic treatment was less expensive to deliver, and the patients who received it were in a superior state of oral health compared to the children with the amalgams. This study provides unequivocal evidence that an inexpensive treatment schedule based upon the NSPH can be successful. The study was not designed to separate out how much of the effect was due to the mechanical debridement and how much was due to the fluoride. Lindhe and Axelsson attributed the results to the mechanical component. However, a 10-minute exposure of 5 per cent MFP (approximately 6500 ppm of F) is certain to have some effect on the plaque flora.

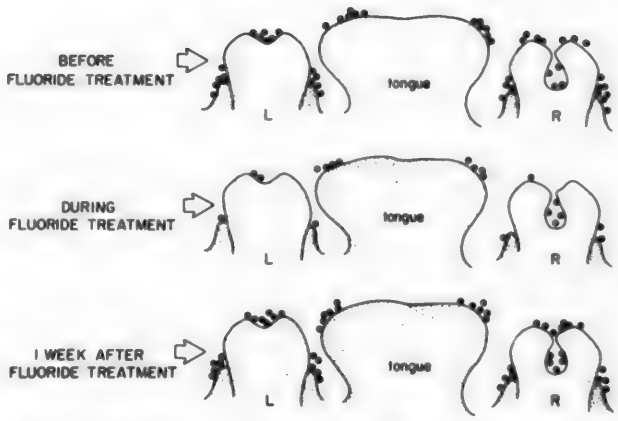

FIG. 1. Treatment based upon the nonspecific plaque theory. ● = oral streptococci.

Irradiation induced xerostomia in cancer patients provides a situation where decay is extensive, predictable and possibly life threatening.[6] In these patients, the cost of a daily fluoride regimen can be justified. The treatment of these patients is not, however, strictly under the NSPH, because a precise diagnosis is used in their selection for treatment, *i.e.*, xerostomia. Daily topical administration of 1 per cent NaF gel in these patients has virtually eliminated caries over a 30 month post-irradiation period.[3] The fluoride suppressed the levels of *S. mutans* for about 6 months compared to the nonfluoride treated control group. These data suggest that the initial effects of the fluoride was to exert a selective antibacterial action against *S. mutans* and possibly other plaque bacteria.

These three studies demonstrate the caries inhibitory effect of topical fluorides when given according to the NSPH using an optimal treatment schedule. But what would happen if treatment did not have to be continuous and universal. In the xerostomia patients, a significant reduction of *S. mutans* occurred in the first few months following F treatment. Could this reduction by itself be responsible for the subsequent absence of caries? In the Cheektowaga study no gel treatment was given in the subsequent two-year period. However, when the subjects were reexamined, the fluoride

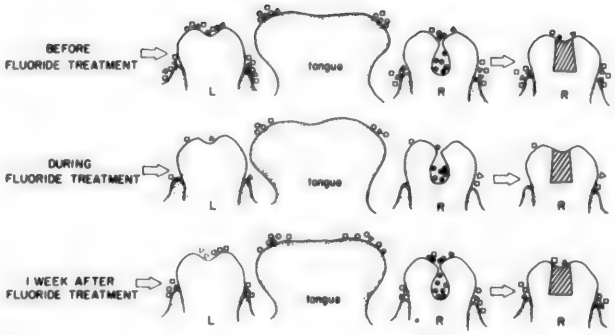

FIG. 2. Treatment based upon the specific plaque theory. ● = *S. mutans*, □ = *S. sanguis*, △ = *S. mitis*, ○ = *S. salivarius*.

groups continued to show about a 55 to 63 per cent reduction in incremental DMFS score compared to the control group.[8] This residual effect of the fluoride treatment is compatible with a therapeutic cure of an infection. Could a specific pathogen have been eliminated, suppressed, or delayed from dominating in the plaque during a period in which the tooth was unusually susceptible to decalcification? These considerations give credence to the SPH.

TREATMENT ACCORDING TO THE SPH

There is no doubt that the topical fluorides exert a direct bactericidal effect on plaque bacteria. But what would happen in the plaque flora associated with dental caries is unique. There is a considerable amount of information that indicates that this is true. Plaques associated with human caries have elevated levels of *S. mutans*, elevated proportions of *S. mutans* and exhibit low levels of *S. sanguis*.[5,17] And what is more, *S. mutans* appears to colonize only the tooth surface and is not found on the oral soft tissue.[9] Thus an antibacterial agent which reduces the plaque flora might selectively reduce or eliminate *S. mutans* from the mouth. This is illustrated in Figure 2. Let us consider the scenario in which no dental restorations are placed.

Approximately 1000 ppm of flouride (F) applied in the gel to the tooth surfaces would have an immediate bactericidal effect on those bacteria which came in contact with it. The organisms which would escape this killing dose would be those buried in thick plaque if no polishing preceded treatment, those buried in the fissures and cracks on the surface, those buried in the carious lesions and those present on the soft tissues. After the F gel is physically removed, the tooth surface will become recolonized by bacteria from any of the above reservoirs. As the saliva flows over the surface, selective adsorption of *S. sanguis* will occur. Adsorption of *S. mutans*, which is of lower probability than *S. sanguis* under normal conditions, will be reduced even more because of the decreased levels of *S. mutans* in the mouth following treatment. The F or any other topically applied agent will most likely not penetrate into fissures, cracks and carious tissue. Bacteria will grow by extension from these sites and recolonize the surface. If the outgrowth occurred from a carious lesion, and if *S. mutans* were a prominent organism in the outgrowth, then an enrichment for *S. mutans* might occur (Fig. 2). This situation might predispose to *S. mutans* infection of the adjacent teeth, leading to decay. If the caries lesion is replaced by a dental restoration as is shown in Figure 2, then this reservoir for *S. mutans* is eliminated and the topical fluoride is more efficient in removing the residual *S. mutans*. Such a combined mechanical and chemical approach, if correct, would predict a therapeutic cure for caries.

A specific effect of fluoride on *S. mutans* in humans was first demonstrated by Woods.[22] He selected patients who had *S. mutans* in their plaques (a bacteriological diagnosis) and treated them with a dental polishing using pastes with and without fluoride. One week later a significant decrease in the proportions of *S. mutans* was found in plaques taken from individuals who were treated with fluoride. We have confirmed this result and have shown that the reduction in proportions of *S. mutans* can persist for up to 12 weeks after fluoride treatment.[16] In these studies teenage boys, living in a rehabilitation center, were selected according to the presence of *S. mutans* in plaques removed from either a single approximal site on the mesial of the lower first molar, or from multiple occlusal fissure sites. The boys were randomly assigned to fluoride (1.23% acidulated phosphate fluoride [APF] gel) or placebo groups. Prior to gel treatment, the average values for per cent *S. mutans* and per cent *S. sanguis* were comparable in each group. Ten 5-minute applications of either the APF or placebo gels in applicator trays were given under supervision for two consecutive school weeks. No prior dental polishing was given. The proportions of *S. mutans* in the single approximal plaque was reduced in the APF group, compared to pre-

treatment values, by 70 per cent one week after treatment, by 53 per cent 6 weeks after treatment and by 73 per cent 12 weeks after treatment. In the placebo group, the proportions of *S. mutans* increased at each sampling period. The same decrease as a result of APF treatment was observed in the pooled occlusal plaques.

The effect on *S. mutans* was selective in that the proportions of *S. sanguis* in the same plaque treatments were not affected by either the APF or placebo treatments. This unexpected result suggested that some unique relationship existed between *S. mutans* and the APF. *In vitro* testing showed *S. mutans*, *S. sanguis* and *S. mitis* to be equally sensitive to fluoride inhibition. This meant that the source of the specificity was not due, at least *in vitro*, to *S. mutans* having a higher tolerance to fluoride. The explanation was found by a consideration of the ecology of *S. mutans* and *S. sanguis* in the oral cavity as depicted in Figure 2. *S. mutans* colonizes primarily the hard surfaces in the mouth such as teeth or prosthetic appliances. *S. sanguis* colonizes both hard and soft surfaces and is among the first organisms to recolonize a tooth after a mechanical polishing.[9] *S. sanguis* is present in higher numbers than *S. mutans* in saliva, which is probably a reflection of it having more oral surface reservoirs which can empty into the saliva. Thus if a tooth surface has been either mechanically cleaned and/or disinfected with an antimicrobial agent, the odds are more favorable for *S. sanguis* to recolonize than *S. mutans*.

This suppression of *S. mutans* following short-term topical fluoride treatment has encouraged us to use this treatment in a realistic clinic setting. Two practicing dentists, Drs. Bradbury and Pink of Brighton and Jackson, Michigan, are assisting us in this regard. Patients who normally come to their office and are diagnosed as having rampant caries are offered the opportunity to enter a program in which, in addition to the normal restorative work, they receive short term applications of topical fluoride or placebo. The actual

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usage of the fluoride is unsupervised. The plaque and saliva of these patients usually contain elevated levels of *S. mutans* so that a diagnosis of *S. mutans* infection is possible. Patient cooperation has been excellent. Preliminary data suggest that the fluoride is suppressing *S. mutans* in *some* treated subjects for about 3 months after treatment. In one practice, only 5 to 6-year-old children without permanent molars have been treated. Early clinical results obtained several months after eruption of the permanent molars suggest that the fluoride is reducing the incidence of caries in these teeth compared to the placebo group. These results are preliminary, but are encouraging in that they offer a reasonable and simple treatment under the SPH for those individuals with rapid and extensive cavitation.

SUMMARY

Fluoride is a chemotherapeutic agent that has no important medical usages and appears to be an unusually safe and effective cariostatic agent. After 30 years of clinical usage, there have been no reports of host sensitivity, bacterial resistance, or suprainfections. When given in therapeutic dosages under the auspices of the NSPH it can essentially prevent caries. Even when given in suboptimal dosages in dentifrices, a 20 to 30 per cent reduction in caries is noted. Fluoride may work by eliminating *S. mutans* from its main, if not only oral reservoir, the tooth surface. In this sense, intensive topical fluoride treatment may affect a bacteriological cure of caries which would not be seen with water fluoridation or with fluoride dentifrices and which would explain the persistent anticaries action of topical fluorides. Future investigations should address themselves to finding the optimal treatment schedule, *i.e.* one that can be easily implemented and which will provide maximum benefit.

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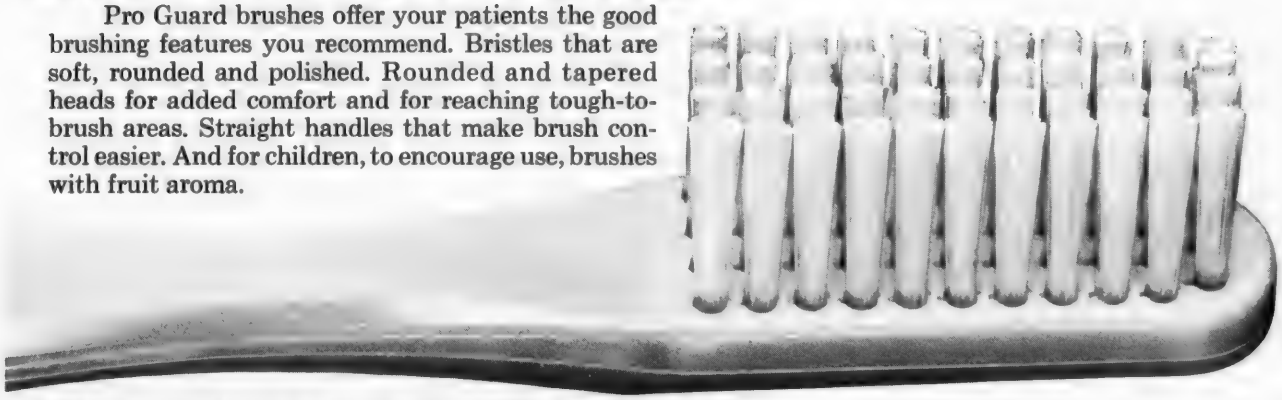

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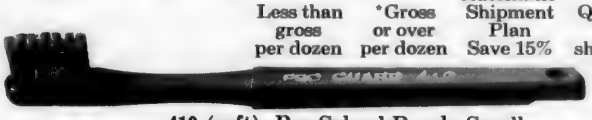
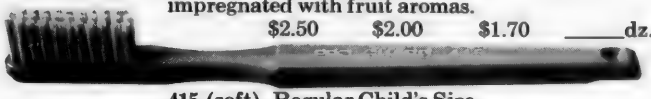
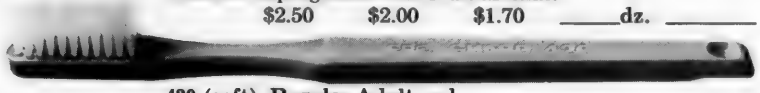
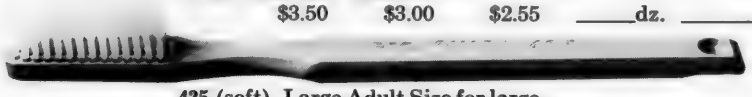
 **410 (soft), Pre-School Brush. Small and compact: 5/8" head. Handles impregnated with fruit aromas.**	$2.50	$2.00	$1.70	_____dz.	_____
 **415 (soft), Regular Child's Size. Handles impregnated with fruit aromas.**	$2.50	$2.00	$1.70	_____dz.	_____
 **420 (soft), Regular Adult and Youth Size. .008" bristles.**	$3.50	$3.00	$2.55	_____dz.	_____
 **425 (soft), Large Adult Size for large dental arches. Soft bristles.**	$3.50	$3.00	$2.55	_____dz.	_____
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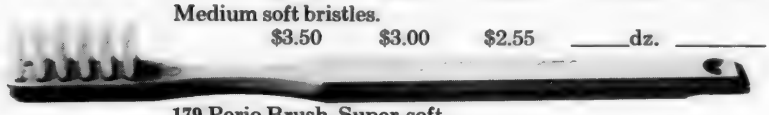 **179 Perio Brush. Super-soft .007" bristles spaced for sulcular brushing techniques.**	$3.50	$3.00	$2.55	_____dz.	_____

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The Role of Dentistry in the Treatment of Malignant Disease†

Raymond L. Braham, B. D. S., M.Sc.D.*

To an unfortunately large number of dentists the word *cancer*, in relationship to their profession, signifies *squamous cell carcinoma*. All too many, if questioned as to what they see as being the role of the dentist in the treatment of cancer, will respond that it involves the provision of prostheses to repair the mutilation and restore loss of function caused by radical surgery.

Today, however, nothing could be further from the truth. A period of less than a generation has seen the life expectancy of patients suffering from malignant disease increase dramatically! This is especially so in the case of children, in whom cancer has been shown to be the leading cause of death, second only to traumatic accidents, in the United States.

It is the purpose of this paper to show how the dentist, working as an essential part of a team, can provide an invaluable contribution to the treatment and possible recovery of the patient.

Various factors have combined to bring about this dramatic improvement in the prognosis of the cancer patient,[12]: (1) New antineoplastic agents are constantly being developed and refined. Such drugs include the antimetabolites and antibiotics such as Adriamycin. (2) New techniques have been developed, such as combinations of radiotherapy and chemotherapy, combination chemotherapy, and innovative methods of utilizing old drugs, such as very large doses of methotrexate with citrovorum rescue. (3) Better supportive therapy: As improved antibiotics, platelet transfusions, and granulocyte transfusions have become available, so it has been possible to minimize the chances of fatal toxicity due to infection or hemorrhage. (4) The development of the concept of "Team Approach and Total Care," as originally propounded by Farber.[6] This entails total collaboration between specialists and generalists involved in every aspect of patient care. It is dedicated to the application of every known means of therapy, particularly the multimodal and interdisciplinary approach. It covers all aspects of patient care through definitive therapy and family support. The "Team" includes all the professionals and paraprofessionals who are involved in the care of the patient, and is under the sole direction of the Oncologist. At the Children's Hospital at Stanford, Palo Alto, California, the concept has been extended to include two highly important members as a part of the treatment team: the patient and the patient's family. Their informed and active involvement has been found to contribute greatly to the success of the patient's therapy. (5) The most important factor is the philosophy of the therapeutic approach whereby the patient and family are given certain long-term goals, this being directed towards the eradication of disease and a return to normal lifestyle as soon

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as possible. The all important factor here is the understanding that the disease is potentially lethal. The patient is treated with the expectation that he is going to do well, unless fate proves otherwise. If therapy has been unsuccessful in the past then the future holds the prospect of something that will work. The achievement of this goal is the target of every member of the team, the patient, and his family. Unless this approach is adopted the four previous factors will be worthless, no matter how great the advances made therein.

As a vital member of the treatment team the dentist has the responsibility of insuring the oral health and well being of the patient. As will be shown later, the occurrence of dental caries and/or oral infection can severely compromise, and even halt, the treatment of the neoplastic disease. To this end the dentist must work with the team, in close consultation with the oncologist, in order to prevent and treat all dental and oral problems.

From the foregoing it should be apparent that the dentist can be involved in the treatment of two specific categories of patient: (1) those with oral cancer; (2) those who are suffering from malignant disease in various parts of the body, but who are exhibiting oral, head, and neck complications as a result of anticancer therapy.

TREATMENT OF INTRAORAL MALIGNANCIES

To treat an intraoral malignancy correctly necessitates a complicated interdisciplinary and multimodal approach involving the cooperation of surgical, radiological, and dental specialists. The essential requirement, in developing a plan of action, is consultation and careful planning.

In general, the overall survival rates and treatment results of patients with oral cancer leave considerable room for improvement. Factors which contribute to these poor results are malnutrition, alcoholism, smoking habits and superimposed infection. Furthermore, the patients often present with the disease in an advanced stage. Treatment of the malignancy usually requires a preliminary period of preparation of the patient, including alimentation, local improvement of the state of the oral tissues, and psychological therapy.

Definitive therapy, whether the modality be surgical or radiotherapeutic, should never be instigated without a positive diagnosis of malignancy, confirmed by biopsy. Exceptions to this rule are very small lesions which should only be biopsied if first seen by the specialist who will be carrying out the treatment. If a very small lesion is biopsied, there is frequent distortion of consistency and appearance of the tumor, which prevents proper evaluation of its extent.

One of the most effective means of treatment of intraoral malignancy is surgery. It enables all significant margins to be examined and some prognosis to be hazarded regarding eventual outcome. If a lesion is removed with adequate margins a reasonable degree of success is assured.

Depending upon the extent and location of the surgery it may be necessary to provide a prosthesis. The detailed ramifications of this statement do not come within the scope of this paper, but it should be borne in mind that total oral health and adequate eating ability are essential to complete recovery.

DENTAL CARE AND IRRADIATION TREATMENT FOR MALIGNANCY

If radiation is to be used in the treatment of head and neck cancer it is essential that the patient be subjected to the most stringent dental care. The delivery of such care should be divided into three major categories: A) Pre-irradiation; B) During irradiation; C) Post-irradiation.

There are very specific aims for a patient who is to be irradiated, as far as dental care is concerned. The incidence and severity of bone necrosis must be decreased. The incidence and severity of post radiation dental caries must be reduced. In the case of a patient who is totally or partially edentulous, it is the ultimate aim to fit dentures when treatment reactions have abated.

Prior to radiation therapy the patient should be carefully evaluated and the oral cavity put in completely caries- and infection-free condition. Teeth which are badly involved periodontally should be extracted. Endodontic therapy should be carried out on pulpally involved teeth, but only if the eradication of all infection can be guaranteed. If pulpal therapy is contemplated in primary teeth then the medication used should be formocresol, since the failure rate of the calcium hydroxide pulpotomy is too great to warrant the risk of subsequent infection. All teeth with carious

Fig. 1. Post-radiation desquamation of tongue.

lesions should be restored, if restorable, otherwise they should be extracted. Existing restorations that show evidence of marginal deterioration should be replaced. A strict program of oral hygiene should be instituted and scrupulously maintained. In short, the mouth must be in such a good condition, pre-irradiation, that therapy for the malignancy will not be compromised by dental problems which could have been avoided. This pre-irradiation treatment may necessitate the surgical preparation of the alveolar ridges, so as better to accommodate a prosthesis later on. Antibiotic coverage, during the healing stage, is a worthwhile prophylactic consideration post surgery prior to irradiation.

There are five possible oral complications of cancer radiotherapy which require the most careful attention by the dentist: (1) Irradiation mucositis; (2) Xerostomia; (3) Ageusia—Hypogeusia, (absence of, or lowered, taste sensation); (4) Post-irradiation caries; (5) Radionecrosis.

Mucositis. A severe mucositis usually develops during, and subsequent to radiation therapy. The initial reaction is a reddening of the mucosa, followed by a whitening, sloughing, and desquamation of the epithelial cells (Fig. 1). The degree of mucositis is proportional to the overall dose, length of dose treatments, number of doses given, amount of tissue irradiated (and its type), and the specific type of radiation equipment used. Apart from the severe pain experienced by the patient, as a result of the mucositis, the denuded areas of oral mucosa provide portals of entry for infection which may compromise the cancer therapy. Treatment of the condition is symptomatic, its aim being both palliative and antiseptic. Dilute salt and soda solutions may be used as mouthrinses, these also helping to remove the oral debris. Demulcent mouthrinses, based on glycerine, and containing bicarbonate of soda and thymol, (Glyco-Thymoline*), also provide a degree of symptomatic relief. Viscous xylocaine has also been used with varying degrees of success to alleviate the pain of mucositis. It may be used *ad lib*, but care should be taken before meals lest the gag reflex be abolished and food accidentally aspirated. Yet another solution that shows considerable promise in alleviating severe mucositis is a 20 per cent solution of Colloidal Silver Iodide,** used *ad lib* as a mouthrinse. This may be used up to four weeks without any harmful effects, which is usually ample time to control the problem. This has the additional advantage that no organisms will live in the presence of the salts of heavy metals. The chloride and iodide of silver are the only two halides which do not cause argyria.

Xerostomia. When more than 5,000 rads of radiation are directed at the salivary glands they become fibrosed and their secretory activity falls off very markedly. There is not a total absence of saliva, but what is left is of a very creamy, thick, ropey nature which, to all intents and purposes, creates a "dry mouth." This is especially the case if bilateral radiation ports are employed in the treatment of nasopharyngeal rhabdomyosarcomas, both parotid glands being irradiated. This condition can precipitate oral infection, predispose to caries, and make it very difficult for the patient to wear dentures. With reduction of salivary flow, its protective action on the exposed surfaces of the teeth is removed. A result is that

* Kress and Owen, Bel Air, Maryland.
** Neo-Silvol, Parke-Davis, Detroit, Michigan.

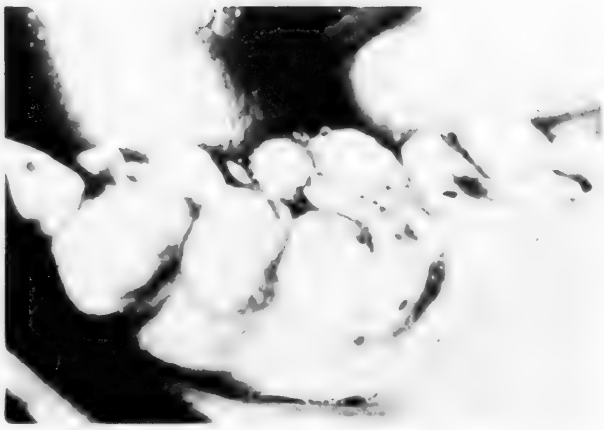

Fig. 2. Radiation caries.

the teeth tend to become extremely sensitive to hot and cold stimuli.

Xerostomia is a very difficult problem to alleviate. Many techniques have been attempted to solve the problem, from demulcent lozenges, to glycerine mouthrinses, to pilocarpine. None has provided truly lasting relief. Recently, a synthetic saliva has been tested, which seems to show great promise. The basis of this product is carboxy methylcellulose and saline, with various salts and other agents added to simulate natural saliva, and buffer it to the same pH.

Loss of Taste. Hypogeusia has been found to develop at around 3000 rads. The condition becomes permanent over 6000 rads. Conger[2] has shown that the sensory impairment is due to irradiation damage to the microvillae, or surfaces of the taste buds. Varying degrees of recovery occur with doses below 6000 rads. The recovery is apparent within 60 to 120 days and, in time, may even be complete.[1]

Post-irradiation Caries. Silverman *et al*.[11] described the condition known as post-irradiation caries. It is a delayed reaction occurring anywhere between 2 and 10 months post therapy. Various reasons have been put forward as to the cause: A) reduction of salivary gland activity with increased caries susceptibility; B) heavy plaque formation; C) fair to poor oral hygiene; D) reduction of the pH of saliva; E) an actual alteration in the enamel structure of the teeth. The main factors appear to be the decreased saliva and reduction of pH. Figure 2 shows a case of severe enamel breakdown occurring approximately 10 months post-irradiation. Treatment of the problem is by full coverage of involved teeth (stainless steel crowns in primary teeth). The condition may be prevented by following the routine described by Daly *et al*.,[3] using fluoride gel applications for 5 minutes per day in a soft vinyl custom fluoride carrier. Scrupulous attention to oral hygiene is the rule.

Necrosis. King *et al*.[9] have described four major sources of necrosis in the oral cavity: A) trauma; B) infection; C) irradiation; D) a combination of the previous three factors.

Trauma may be due to ill-fitting dentures, tobacco, alcohol, or exposure to heat or cold.

Infection of irradiated tissues can occur from any source, the tissues being much less resistant to normal wear and tear. Poor oral hygiene only serves to aggravate the problem.

Radionecrosis usually occurs with definite levels of radiation. Lowering the dose is a false compromise for obvious reasons. Because the blood supply of irradiated tissues is markedly reduced they are much more susceptible to infection. This is why it is essential for a'l invasive procedures to be completed prior to radiation therapy. Figures 3 and 4 show reaction and

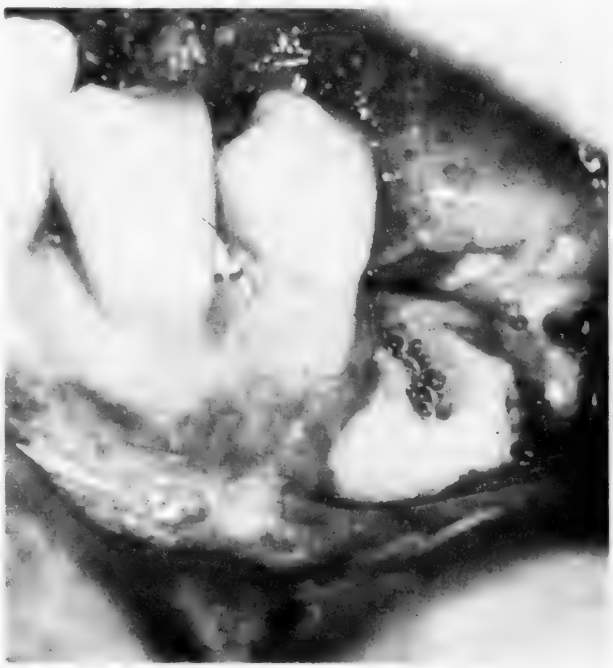

Fig. 3. Osteoradionecrosis.

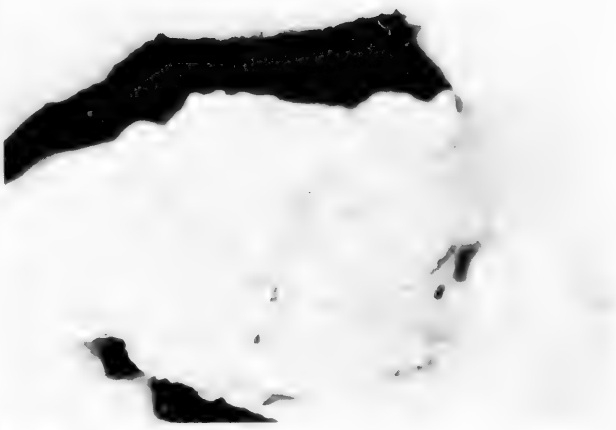

Fig. 4. Osteoradionecrosis.

necrosis in the oral cavity due to post radiation infection.

Trismus. This is another problem of the cancer patient who has received radiation therapy to the head and neck region. It usually becomes apparent within 3 to 6 months post-therapy, and is caused by fibrotic changes in the individual units of the muscles of mastication. The problem should be anticipated by a program of exercises designed to keep these muscles in constant action, thus preventing them from fibrosing as a result of inactivity. This necessitates close cooperation between the dentist and the physiotherapist.

The degree of trismus that occurs often depends on whether the irradiation was bilateral or only unilateral. The exercises should be designed so as to be relatively simple to perform. Opening and closing the mouth as wide as possible 20 times, each group of exercises being repeated three or four times a day. Once the trismus has manifested itself, it is essential to record the degree of opening at regular intervals. The patient is then instructed in intensive home exercises in an attempt to regain the lost space. If these exercises fail it is probably necessary to resort to various types of prosthetic appliances with springs and elastics in order to render the patient some mechanical assistance in stretching and exercising the muscles of mastication. The design of these appliances is very much a test of the dentist's and physiotherapist's ingenuity!

Pediatric Patients. Pediatric patients suffering from malignancy, be it generalized or head and neck in location, are not often subject to squamous cell carcinoma. The tumors encountered are usually soft-tissue sarcomas, especially the rhabdomyosarcoma and the neuroblastoma. This latter is the second most common malignancy of children, being superceded only by leukemia.[4] For obvious reasons there is little time between diagnosis, decision as to mode of action, and initiation of therapy in these patients. Their dental treatment is conservative. They are placed on a careful oral hygiene and preventive program and all associated with them are impressed with the urgency for long term preservation of all teeth present at the time of irradiation. Radiation to the primary teeth and jaws is often found to inhibit further growth of developing teeth and bones. As a result, the permanent dentition will be deficient. Therefore, all primary teeth present in the mouth should be retained as long as possible. Hence the necessity for the previously described home fluoride applications. One of the major problems in the pediatric age group is that of motivation.

Geriatric Patients. The geriatric patient is best managed, throughout, in a conservative manner. Heroic measures can serve no real purpose in these patients, and it is far better that their dental treatment be conservative and palliative than that they be subjected to long and involved dental procedures which only serve to weaken them psychologically.

CANCER CHEMOTHERAPY AND ITS ORAL RAMIFICATIONS

The past decade or so has seen a dramatic increase in the development and use of antineoplastic drugs for the treatment of disseminated neoplastic conditions. These agents are also being used to supplement or complement surgical and radiation therapy.

Put into simple terms, cancer chemotherapy aims to preferentially destroy cancer cells while sparing, within the bounds of feasibility, the normal cells of the body. Cancer cells exhibit the characteristic of rapid generation. As a result they are actively destroyed by agents which inhibit cell replication. These agents include antibiotics, antimetabolites, plant alkaloids and numerous other compounds.[5] Each of the foregoing agents, or groups, exhibits its own antitumor activity. The latest trend, however, is towards combination therapy, using the various drugs in combinations or sequences that have the following advantages:

(continued on page 34)

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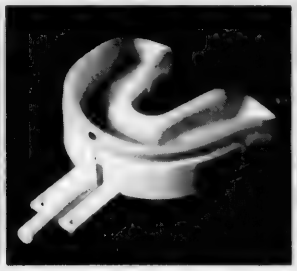
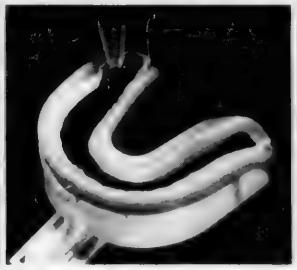


2) A plastic tray holds this air cushion membrane which adapts to the arch.



3) A paper insert is saturated with fluoride.

4) When the patient bites, the membrane forces the fluoride all around the teeth including the interproximal surfaces. *Saliva is sealed out.*

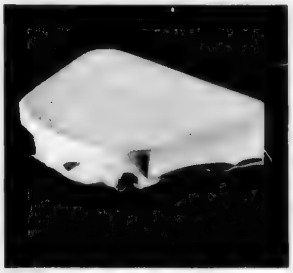


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Fig. 5. Multiple petechiae of palate due to pancytopenia.

(continued from page 32)

(1) Lower doses of individual agents may be used, since the overall spectrum of activity is widened. (2) Lowering individual doses reduces the toxic side effects of various drugs.

The cellular reproduction of the bone marrow and the epithelial lining of the oral cavity and gastro-intestinal tract is extremely rapid. These rapidly dividing cells are highly susceptible to the action of the antineoplastic agents. As a result they become suppressed. Because the mouth is a prime focus for thermal, physical, and chemical injuries there exists a gateway for infectious, hemorrhagic, and neurologic complications, unless the problems are diagnosed early and managed with the utmost care and consideration. If these complications are allowed to become dominant they will hinder or negate the anticancer therapy to the extent that the patient may even succumb to the side effects or complications rather than to the actual malignancy.

HEMORRHAGIC COMPLICATIONS

The antineoplastic agents in use today have the property of profound and long-lasting depression of the bone marrow. By interfering with the production and maturation of megakaryocytes they cause thrombocytopenia. When the platelet count of the blood drops below 20,000/mm^3, oral bleeding commonly occurs. The hemorrhage tends to occur at points where the mucosa is subjected to trauma such as food impaction. It is an intermittent oozing, recurring as the soft, friable clots form and are continually knocked away by traumatic influences.

The hemorrhage is relatively easily controlled by transfusions of platelets. One unit of platelets will increase the platelet count of the recipient by 13,000 to 15,000/mm^3 per mm^2, of body surface.[5] However, the platelet half-life is only 24 to 48 hours. Therefore platelets in doses sufficient to raise the count 30,000 to 50,000/mm^3 have to be administered 2 or 3 times each week, in order to maintain the platelet count above 20,000/mm^3, until bone marrow recovery is sufficiently far advanced to restore the platelet formation.[7]

During periods of thrombocytopenia it is not feasible to carry out normal oral hygiene procedures, since such activities as tooth brushing and flossing will cause severe hemorrhage. Oral hygiene should be attempted by the judicious use of rinses with hydrogen peroxide, well diluted, so as to attempt the removal of oral debris with minimum trauma.

Figure 5 shows multiple palatal petechiae due to pancytopenia.

INFECTIOUS COMPLICATIONS

The patient suffering from nonimmunosuppressive malignant disease is predisposed to infection by cancer chemotherapy. Those patients suffering from leukemia, lymphoma, and myeloma, (these being diseases that depress one or other of the immune response mechanisms of the body) are even more disposed to infections by the antineoplastic drugs. The chemotherapeutic agents lower the patient's immunity by reducing leukopenia, inhibiting antibody responses, blocking the mononuclear phase of the inflammatory reaction, and abolishing the development of delayed hypersensitivity.[8] By interfering with the growth and development of the cells of the oral mucosa, many of these agents bring about a lowering of the tissue barrier against infection.

Most of the opportunistic infections in patients receiving cancer chemotherapy are bacterial, fungal, or mixed fungal and bacterial.[5] Viral infections are, fortunately, relatively infrequent. When they do occur they are usually in the form of *Herpes simplex*. In uncomplicated cases the herpetic infection follows its usual course of approximately 10 days. However, oral herpes can lead to pulmonary complications and infections

disseminated throughout the body, so it should not be treated lightly.

With the advent of the broad-spectrum antibiotics and penicillinase-resistant penicillins it has become easier to control the gram positive Staphylococcal and Streptococcal infections that used to predominate. The result is that one now finds more and more opportunistic gram negative infections occurring. Pseudomonas, a relatively harmless organism in the healthy individual, becomes devastatingly pathogenic in the immune deficient patient, being even more dangerous because it is extremely hydrophilic and found, very commonly, in the hospital environment. Precautions against this organism include insuring that toothbrushes are not left on the side of the washbasin in a pool of water, but are rinsed out carefully, then shaken thoroughly, and hung to dry in the toothbrush rack. Water containers should be disposable, and children must not be allowed to indulge in the all too common practice of using each others, or in the occasional cases, "communal" toothbrushes. This last is occasionally seen in large families, where the parents are trying to cut down on overheads. Water irrigating devices are totally to be discoraged since they run the risk of pumping organisms and infection into the blood stream. Antibiotics such as Amphotericin-B that are used to control the gram negative infections, are so highly toxic in themselves that every effort should be made to avoid the risk of a patient contracting one of these superinfections.

The most common opportunistic fungal infection is Candidiasis, due most often to *Candida albicans*. Early Candidiasis may be treated with 1:1,000 Nystatin mouthrinses, or dilute acqueous benzalkonium chloride, (Zephiran). Severe systemic infections require the administration of intra-venous Amphotericin-B. This can cause renal shutdown, so it has to be very carefully monitored.

CYTOTOXIC REACTIONS TO CHEMOTHERAPY

Some of the antineoplastic antibiotics, specifically Adriamycin, its structural analog Daunomycin, and Actinomycin-D, are destructive to tissue to such an extent that the effects exceed that of simple inhibition of cell proliferation.[5] All three will cause skin necrosis at the sites of local infiltration. Each is cytocidal to the oral and gastro-intestinal mucosa, causing severe ulceration of all oral surfaces. Treatment is essentially symptomatic and palliative as previously described under mucositis.

NEUROLOGIC COMPLICATIONS

Some of the anticancer drugs exhibit varying degrees of neurotoxicity. Perhaps the one that causes the most obvious symptoms is vincristine sulfate (Oncovin). The complications are manifested mostly as neuropathies of both sensory and motor nerves. Dose and duration are directly related to degree of reaction.[10] Trigeminal and facial nerve degeneration, caused by vincristine, can produce a neuralgic pain very akin to that of toothache, which is extremely difficult to

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diagnose differentially, unless one is on the lookout for it.

SUMMARY

Assuming that the various blood components are at satisfactory levels, the following generalities may be made:

(1) Infection must be prevented. Teeth with total pulpal necrosis should be extracted—if radiation is contemplated, all surgery should be completed at least 10 to 14 days beforehand. Formocresol pulpotomies should be carried out on primary teeth with partial necrosis of the pulp. The calcium hydroxide pulpotomy is to be avoided in view of its relatively high rate of failure. Endodontic therapy is only to be encouraged if total elimination of all foci of infection can be guaranteed. No procedures should be carried out in the presence of infection unless the supervising onclogist so directs, and then only with adequate antibiotic coverage. Topical applications of mild antiseptics should be used for ulcerated areas. Only soft, multi-tufted toothbrushes should be used; they must be air-dried. No water irrigation devices should be used. Scrupulous oral hygiene must be maintained. Use dental floss with great caution.

(2) Pre-irradiation care: Extract teeth with questionable prognosis which are in the field of radiation. All extractions to be completed 10 to 14 days prior to therapy. Replace broken or deficient restorations. Remove orthodontic appliances.

(3) Post-irradiation care: Daily self-application, for 5 minutes, of 1 per cent neutral fluoride to thoroughly cleaned teeth. Apply xylocaine, (viscous,) p.r.n. Liberal use of synthetic saliva.

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Caries Prevention by Electroless Deposition of Metals

A Preliminary Primate Study

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The dental profession's quest for a durable material that could be used to coat teeth and prevent decay has been long and relatively unsuccessful until the last decade.[2,10,13]

During the 1970's several pit and fissure sealants have been tested with varying success. The materials (or methods) used were cyanoacrylate,[5] polyurethane,[12] bis-GMA systems,[3,4,6,11,14] polyphosphonates[1] and others. In all cases, the enamel was etched with acid before the sealant was applied. The tensile bond strength of various systems was reported by William, Von Fraunhofer, and Winter[15] who found greater retentive strength with the bis-GMA system. The effects of variable methods of application of bis-GMA systems demonstrated better results with a low viscosity material.[7] Duration and percentage of retention were reported from bis-GMA systems by Harding and Buonocore,[7] Burt *et al.*,[4] Newbrun[12] and Horowitz, Hiefetz, and McCune.[9] The retention of the sealant was reported at two years as 73 per cent completely retained, 11 per cent partly retained and 16 per cent completely absent.[9] A similar study[4] at 6 months reported 39 per cent of sealant intact, 44.2 per cent partially present and 16.8 per cent completely lost. The effectiveness of the sealant in preventing caries was reported as 67 per cent at two years.[7] Hinding[8] and Rock[4] have reported extended cariostasis even after partial loss of the sealant.

This brief survey of the literature indicates the problems involved with these systems include: (1) the loss of the sealant[8,9]; (2) the loss of part of the sealant leaving rough margins[6]; (3) variability of success according to method of application[7]; (4) failure to penetrate pits and fissures[6]; (5) leaking margins[6]; and (6) inability to protect interproximal surfaces.

In 1972 the U.S. Army Medical Research and Development Command in conjunction with University of Missouri-Rolla Materials Research Center at Rolla, Missouri, began research into a new method of tooth protection. This involved the electroless deposition of metal onto a prepared enamel surface and was described by O'Keefe *et al.* in 1974.[13] This method of protecting teeth promises to obviate certain of the problems associated with the present pit and fissures sealants.

The clinical trials of this unique method of tooth protection in primates and preliminary studies of humans at the U.S. Army Institute of Dental Research constitute the subject of this paper.

METHOD AND MATERIALS

Six Macacus Rhesus monkeys were anesthetized with .5 ml Sernylan (10 mg) and .5 ml of Pentobarbital (64 mg). The mouth of the subject was propped open allowing ready access to the posterior teeth of both arches. In each animal the maxillary left and mandibular right posterior

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Fig. 1. One week sample coated with $AgNO_3$. The entire occlusal surfaces of the teeth are coated and parts of facial and lingual areas are irregularly coated. Areas subjected to occlusal wear, appear a lighter gray.

quadrants were isolated with cotton rolls and used as experimental sites. Occlusal surfaces of the experimental posterior teeth were etched with 50 per cent H_3PO_4 for one minute, then rinsed with distilled H_2O and dried with compressed air. One of the following metal solutions, 1N AgF, 1N $AgNO_3$, or $AuCl_3$, was applied to the etched occlusal surface with cotton tip applicators and reduced with hydrazine concentrations of .75 per cent or 1.5 per cent. The quadrants treated with silver compounds received eight repetitions of the above metal coating sequence and the gold received fourteen. Following a metal coating of AgF

Fig. 2. One month sample coated with $AgNO_3$. The areas subjected to occlusal wear are nearly devoid of metal.

Fig. 3. Two months sample coating with $AgNO_3$. These samples are almost identical to the one month sample.

one animal was treated by condensing and burnishing amalgam* on the coated occlusal surfaces. All arches were immediately inspected for any clinical evidence of injury. The animals were placed on a hard food diet** for the duration of the experiment.

All animals were anesthetized and examined at 1 week, 1 month, 3 months, and 6 months for evidence of retention of the metal and to note any adverse effects which might have occurred to the tissue. Each arch was photographed at each time period.

RESULTS: METAL COATED SURFACES

Following application of the metal solutions of AgF, $AgNO_3$ or $AuCl_3$, there was no clinical evidence of any injury to the soft tissues, although some solutions had inadvertently contacted the gingiva.

One Week. The gingival soft tissues around the coated teeth appeared normal when compared with the opposite control arches.

The metal coating on the teeth had oxidized, presenting a characteristic gray black color. All of the metallized surfaces were smooth, with the metal firmly adherent and uniformly dark in color. In the area of occlusal facets the coating showed evidence of wear (Fig. 1). The facets of exposed dentin on the few deciduous teeth coated poorly initially and demonstrated almost complete loss of the coating.

* Dispersalloy, Johnson and Johnson, New Brunswick, N.J.
** Purina Monkey Chow, Ralston Purina Co., St. Louis, Mo.

Fig. 4. Three months sample coated with $AgNO_3$. Although the areas of occlusal wear are increasing in size the fissures remain fully coated.

Fig. 5. Six months sample coated with $AgNO_3$. Change from 3 to 6 months is minimal. Notice even very small enamel pits are still coated.

No clinical difference was apparent between any of the metals, hydrazine concentrations, or application variations.

One Month. All the metallized surfaces except areas of heavy occlusal contact remained identical to the 1-week samples (Fig. 2). The pits and fissures were still coated and appeared free of debris. Areas of exposed dentin was devoid of metal coating. No difference in the metal coating could be detected, regardless of the type of metal or method of application.

Two Months. Except for minimal loss due to occlusal wear, the two-month samples of all types appeared identical to the one-month samples (Fig. 3).

Three Months. All three-month samples were essentially identical with the two-month samples (Fig. 4).

Six-Months. All samples at 6 months resembled the 1 and 2-month samples. All pits and fissures remained coated. The soft tissue was normal and the entire occlusal surfaces remained free of plaque and debris (Fig. 5). Loss of the metal coating had occurred primarily in the areas of heavy occlusal contact showing facets of wear.

RESULTS: TEETH WITH AMALGAM CONDENSED AND BURNISHED ONTO THE METAL COATED OCCLUSAL SURFACE.

One Week. The amalgam was present as small globular masses in all the pits and fissures (Fig. 6).

One Month. The one-month samples were similar to the one-week samples; however, 12 per cent of the occlusal pits and fissures had lost the amalgam. This loss did not affect the subjacent metal coating (Fig. 7).

Two Months and Three Months. These time samples showed a continued slow loss of amalgam from the pits and fissures.

Six Months. The mandibular arches had lost 66 per cent of the amalgam and the maxilla 58 per cent. The plating was generally still intact after the amalgam loss (Fig. 8).

(continued on page 41)

Fig. 6. One week sample of AgF plus burnished amalgam. The areas of wear are a light gray showing the metal is wearing thin. Each pit and fissure still retains the amalgam.

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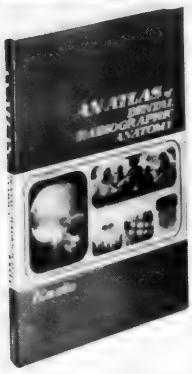

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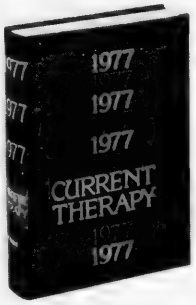

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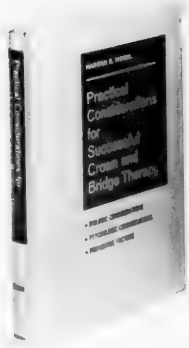

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Fig. 7. One month sample of AgF plus burnished amalgam. The wear facets are almost white showing little remaining metal. The amalgam has been lost from certain fissures.

Fig. 8. Six months sample of AgF plus burnished amalgam. The fissures showing loss of amalgam still retain the metal coating.

(continued from page 39)

DISCUSSION

The electroless plating or metallizing of the enamel surfaces of teeth is a feasible and unique technique. The acid etched enamel surfaces apparently created a reactive surface for metal film adherence, since nonetched surfaces could not be coated. This film of metal persisted in the pits and fissures throughout the 6 months of this experiment, with loss of the coating occurring mainly in areas of heavy occlusal contact. After the first month, only slight changes could be detected in the wear of the metal films.

Examination of the teeth with amalgam overlays demonstrated the feasibility of adhering amalgam to the metal films. In this study the percentage of fissures with amalgam remaining was comparable to the adhesive resin sealant remaining at the same time period as reported by several authors.[6,7,9,12] This demonstrated adherence between these metal coatings and amalgam also suggests their ability to act as an intermediate liner, bonding amalgam restorations to tooth structure.

Preliminary testing of antibacterial *in vitro* and *in vivo* properties of the silver coatings was also accomplished. Paper discs were saturated with either (1) silver fluoride solution, (2) hydrazine solution, or (3) silver fluoride solution, followed by reduction with hydrazine solution. The discs were placed on blood agar plates seeded with the following bacterial species: *Streptococcus mitis*, *Staphylococcus aureus*, *Staphylococcus epidermidis*, and *Escherichia coli*. In addition, enamel cylinders were treated with the silver sealant according to the recommended procedure and placed on the seeded blood agar surfaces.

After 24-hour incubation, inhibition zones formed around all paper discs except those treated with hydrazine solution only. The width of the inhibition zones measured from the periphery of the disc was approximately 5 mm for silver treated discs and 3–4 mm for discs treated with silver and hydrazine solutions. Inhibition zones around enamel cylinders treated as described above were much smaller (approximately 1 mm), possibly because their surfaces are slightly convex, which prevented good contact with the surface of the media.

Preliminary *in vivo* bacterial studies involved the placing of electroless silver coated enamel discs in a palatal prosthesis. This prosthesis was worn in the mouth for various intervals up to 4 days. Scanning electron microscopy of the disc surface revealed infrequent bacteria on the coated specimens, yet the uncoated enamel specimens possessed large deposits of bacteria. When the discs were sectioned it was found the metal film had penetrated the etched enamel surface up to 15 microns.

From this group of preliminary experiments it appears that the electroless coated silver metals possess antibacterial properties.

There is great potential for the use of electroless deposited metals as a preventive material. This

method of tooth protection is not subject to many of the shortcomings of resin type pit and fissure sealants. It is not lost from the pits and fissures, it is antibacterial, and can be used to coat the interproximal surfaces. If used in children, this system has the potential to provide the greatest amount of protection to the dentition at the time of greatest need. It also may be a method of providing protection to the soldier who must undergo long periods of stress and decreased oral hygiene in the field.

The dark color of the oxidized silver coated surface is objectionable, but, if this process is viewed as a preventive technique and is selectively deposited only on proximal surfaces and in pits and fissures, much of the objection due to the color can be overcome. Further, because this coating on smooth surfaces is 12–15 microns thick, it can be removed from flat exposed surfaces during early adulthood if desired.

CONCLUSIONS

Under the conditions of this experiment the following facts have been established concerning electroless plating of teeth: (1) This system of metallizing teeth is feasible. (2) The metal coating is firmly adherent for a period in excess of 6 months. (3) The color is objectionable if the entire crown is coated but appears identical to amalgam if selectively applied to the pits and fissures. (4) Amalgam will interact with the metallized surface. (5) Preliminary studies indicate antibacterial and antiplaque potential. (6) Many of the problems inherent in conventional pit and fissure sealants are obviated.

Other studies are in progress further characterizing and testing this process at U.S. Army Institute of Dental Research and the University of Missouri-Rolla, Materials Research Center.

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1 ☐ Partnership	1 ☐ Orthodontics	1 ☐ Other _____
2 ☐ Group	2 ☐ Endodontics	2 ☐ Control Assistant
3 ☐ Full-time Faculty	3 ☐ Pedodontics	3 ☐ Business Assistant
4 ☐ Part-time Faculty	4 ☐ Periodontics	4 ☐ Hygienist
5 ☐ Other _____	5 ☐ Prosthodontics	5 ☐ Chairside Assistant
YEARS IN PRACTICE	6 ☐ Dental Assistant	6 ☐ Other _____
6 ☐ Less than 2	7 ☐ Other _____	
7 ☐ 2 to 10		
8 ☐ More than 10		

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Journal of PREVENTIVE DENTISTRY

Abstracts of Articles in This Issue of the Journal of Preventive Dentistry
(Remove page, cut along lines, file as 3" x 5" cards)

Loesche, WJ: Topical Fluorides as an Antibacterial Agent. J Prev Dent 4 (January-February) 1977.

Abstract: Topical fluorides may act in part by exerting an antimicrobial effect on plaque bacteria. As with any antimicrobial agent, maximal benefits can be achieved only if the agent is properly given. An optimal treatment schedule for dental caries requires an understanding of the role that bacteria play in dental caries. If decay results from acid production by any or all plaque bacteria, the nonspecific plaque hypothesis, then an effective bactericidal fluoride treatment would have to be given almost daily and would be impractical. However, if decay results from the proliferation and/or dominance in plaque of certain acidogenic organisms such as *streptococcus mutans* and lactobacilli, the specific plaque hypothesis, then the fluoride treatment would be given for a period of time found adequate to eliminate or suppress these organisms in the plaque. This approach would be practical in individuals recognized as caries susceptible.

Braham, RL: The Role of Dentistry in the Treatment of Malignant Disease. J Prev Dent 4 (January-February) 1977.

Abstract: An unfortunately large number of the dental profession and paradental personnel still assume that cancer, in the relation to their profession, means squamous cell carcinoma of the mouth. This paper sets out to distinguish between oral cancer and the oral head, and neck complications associated with cancer therapy. Discussion is made of the dramatic improvement in life expectancy, especially in the pediatric age group, due to newer techniques, agents, and the multidisciplinary "team" approach of which the dentist is a vital part. Discussion is made of the treatment of intra-oral malignancies, with elaboration on dental care and irradiation treatment for malignancy. Specific attention is paid to the five major complications of radiation therapy which are of particular interest to the dentist. The specific problems of the pediatric age group are elucidated and suggestions are made for

Cutright, DE, Woody, RD, O'Keefe, TJ, Hoffman, JI: Caries Prevention by Electroless Deposition of Metals. A Preliminary Primate Study. J Prev Dent 4 (January-February) 1977.

Abstract: A new method of caries prevention by the deposition of metal on teeth without the use of electric currents is described. The deposited metal is firmly attached to the enamel, is bacteriostatic, easily applied and has been shown to resist wear for at least 6 months in all areas not subjected to mastication.

Mellberg, JR: Enamel Fluorides and its Anti-Caries Effects. J Prev Dent 4 (January-February) 1977.

Abstract: Fluoride in sound enamel arises primarily from exposure to systemic fluoride during the period of enamel formation, but can be increased by multiple applications of relatively high potency topical preparations. Low potency preparations do not significantly increase fluoride levels in sound enamel but do increase them in porus or hypomineralized enamel. High fluoride concentrations normally are found in the outer 5% of the enamel or only to a depth of 30 to 50 μm. An increase in enamel fluoride may inhibit caries by increasing the acid resistance of sound enamel or by the combined effect of increased acid resistance and enhanced mineral deposition in porus or hypomineralized enamel. Correlations of enamel fluoride with caries have usually been made using the fluoride levels of sound enamel and often have included studies where fluoride was applied frequently.

attending to the specific oral problems of the groups. The geriatric patient is considered in relation to the overall problem. The author continues with a discussion of the oral ramifications of cancer chemotherapy, paying particular attention to hemorrhagic, infectious, cytotoxic, and neurologic complications. The overall aim of this paper is to show how attention to scrupulous preventive techniques on the part of patient and dentist, together with basic common sense, can help to increase the thrust and effectiveness of cancer therapy.

However, frequent fluoride exposure, especially of low potency fluoride preparations, may produce an increase in the fluoride concentration of demineralized enamel not reflected in the fluoride levels of sound enamel. Evidence correlating caries vs. fluoride levels in sound enamel in the absence of other effects is sparse and evidence of the effect of fluoride levels in hypomineralized enamel vs. caries is even less available. Nevertheless, the evidence supports the concept that both mechanisms are important and that an increase in the fluoride levels in these areas is consistant with an inhibition of caries formation.

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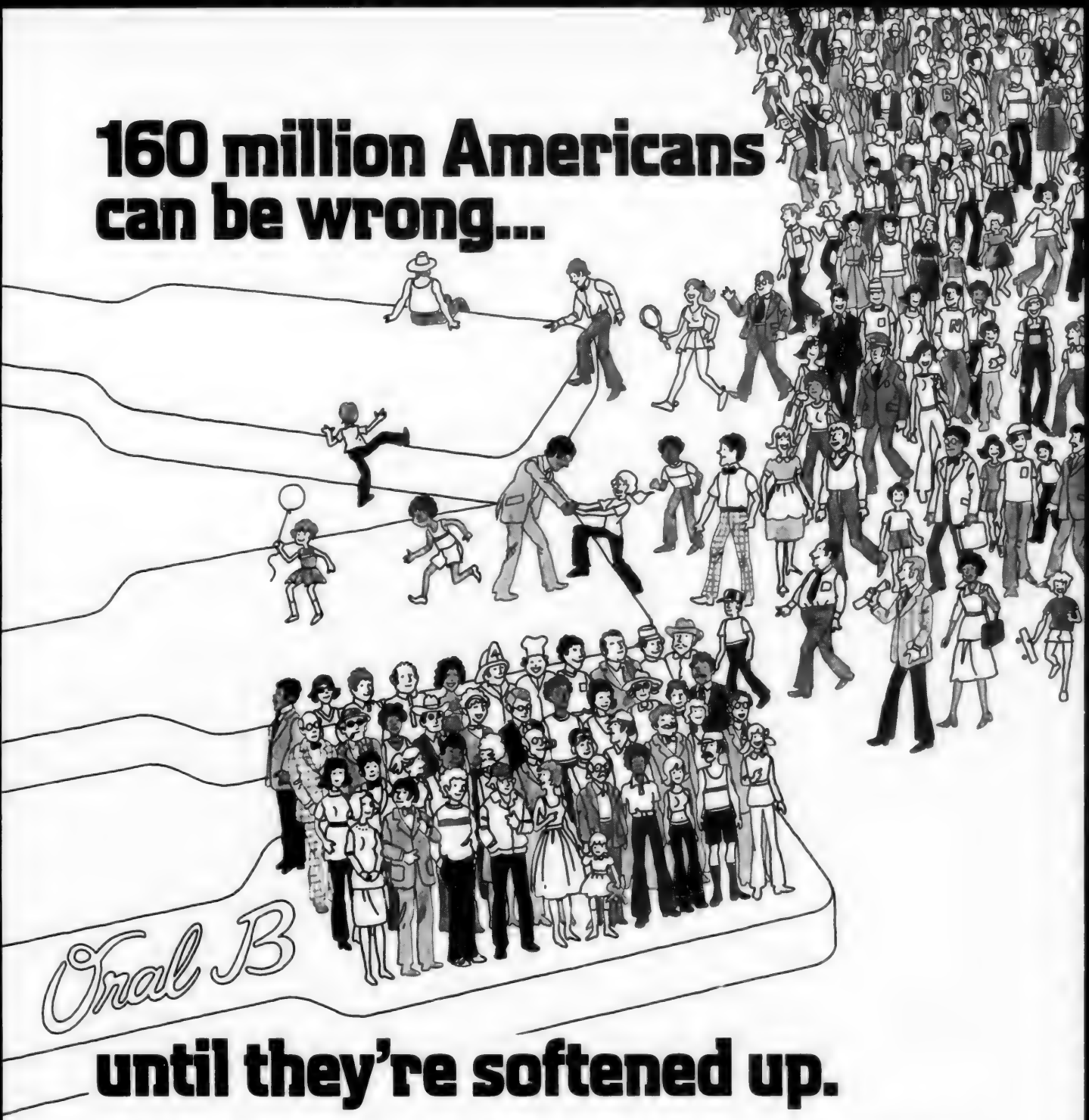

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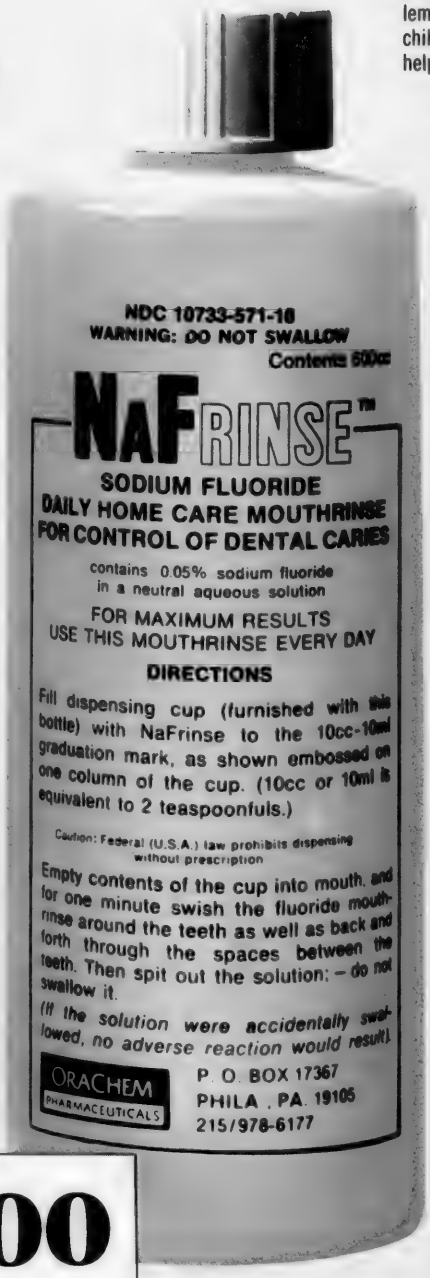
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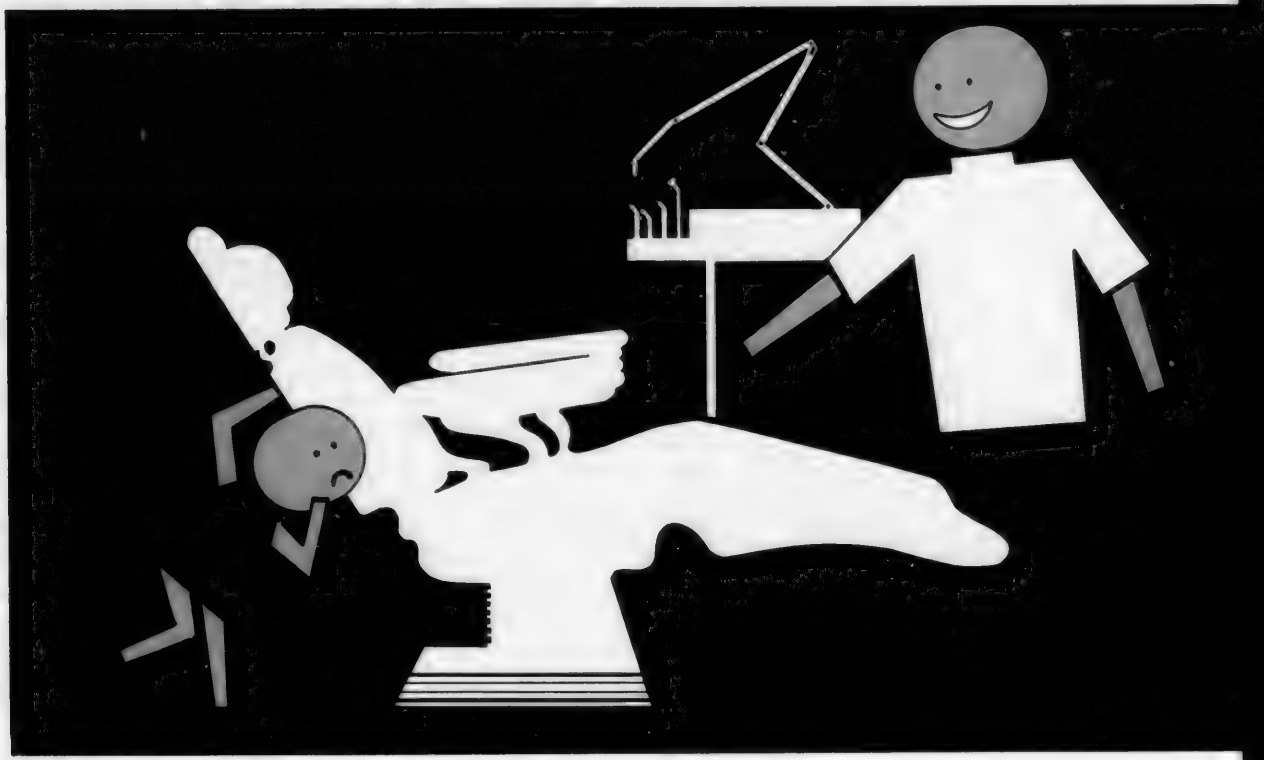

Child Behavior Problems. See Page 23

☐ Evaluation of sugar substitutes in preventive cariology
☐ The prevention of microleakage and achievement of optimal marginal adaptation
☐ The prevention of child behavior problems in the dental office

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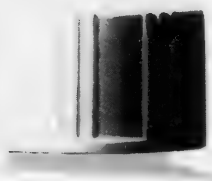

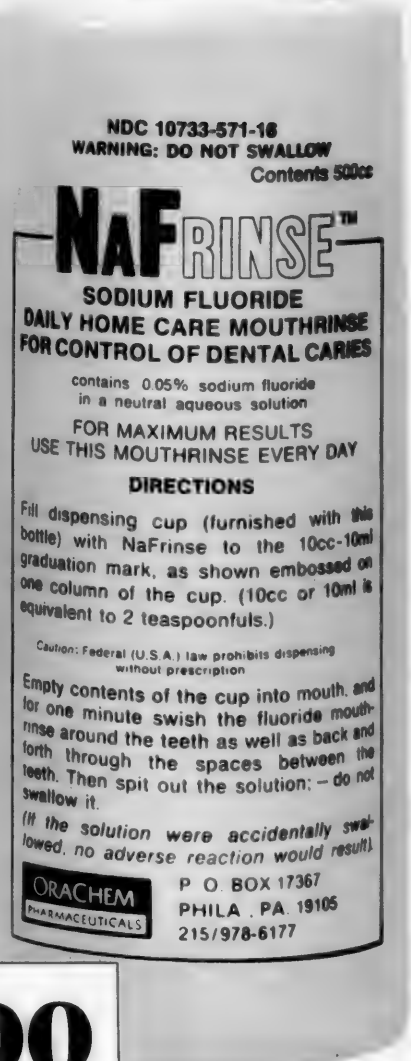
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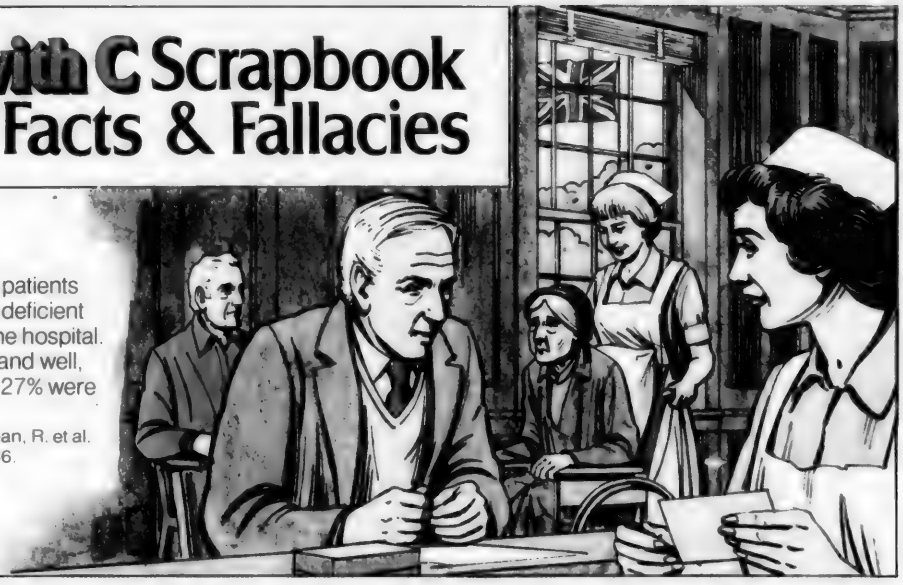

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Griffiths, L.L., Brocklehurst, J.C., MacLean, R. et al. *Diet in Old Age*, Brit. Med. J., 1:739, 1966.

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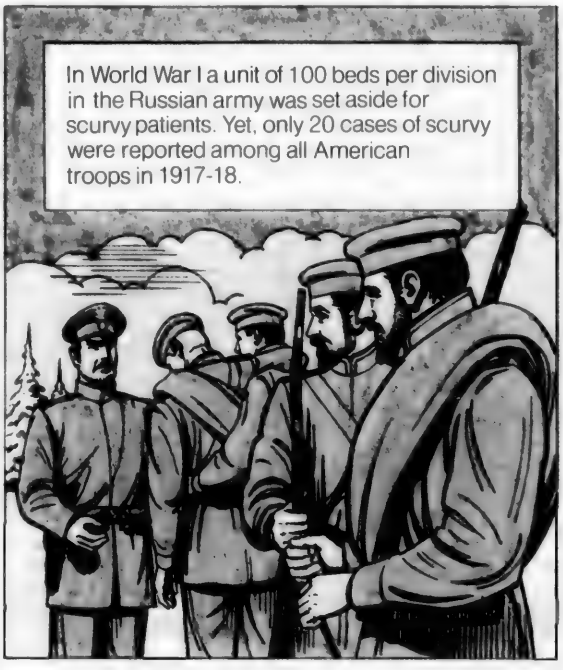

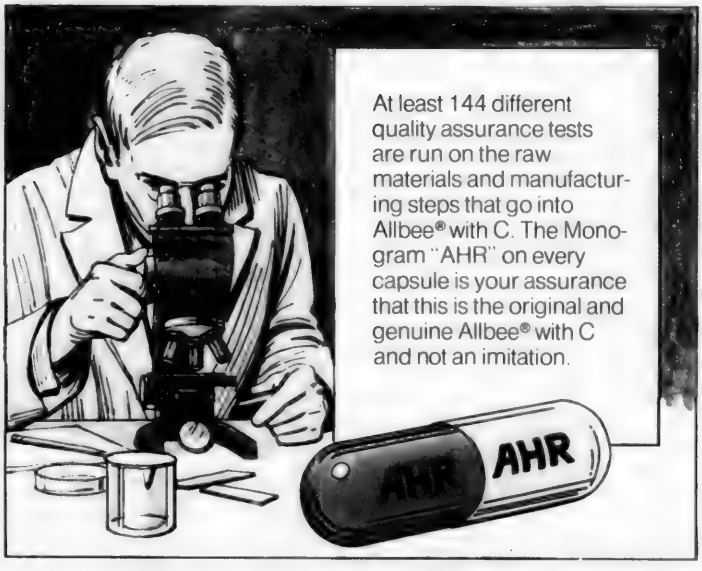

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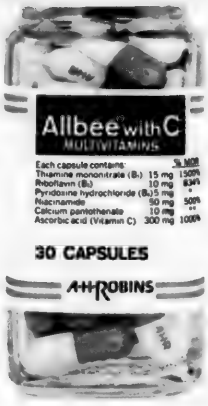

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THE JOURNAL OF

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Vol. 4 • No. 2 March-April 1977

contents

	6	Editorial H. R. Mühlemann, Prof. Dr. Med.
PREVENTIVE CARIOLOGY	**8**	Evaluation of Sugar Substitutes in Preventive Cariology Th. Imfeld, Dr. Med. Dent. and H. R. Mühlemann, Prof. Dr. Med.
	16	The Prevention of Microleakage and Achievement of Optimal Marginal Adaptation Bernard Lüescher, D.M.D., Felix Lutz, M.D., D.M.D., Terry McDermott, D.D.S. and Hans R. Mühlemann, M.D., D.M.D.
BEHAVIOR PROBLEMS	**23**	The Prevention of Child Behavior Problems in the Dental Office Stanley R. Korf, D.D.S., F.A.C.D.

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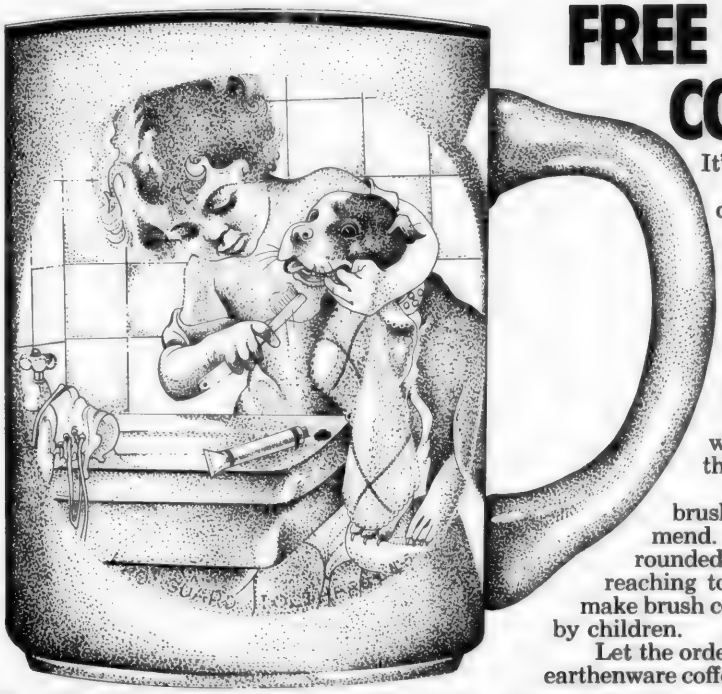

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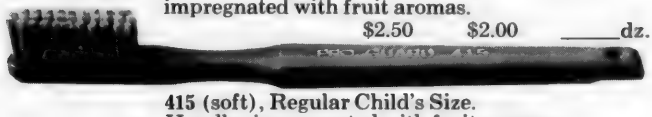				
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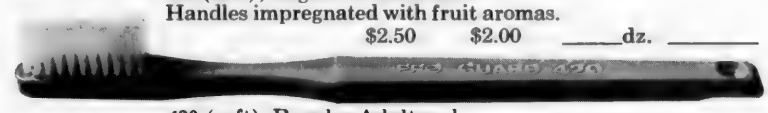				
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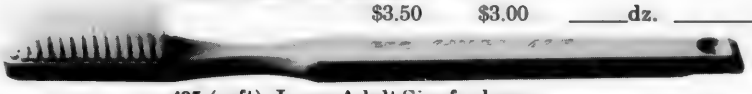
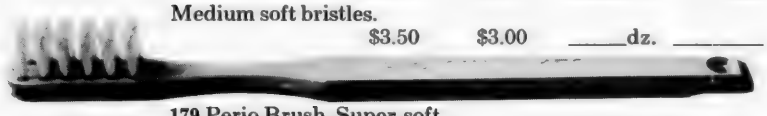
				
425 (soft), Large Adult Size for large dental arches. Soft bristles.	$3.50	$3.00	____dz.	_____
Medium soft bristles.	$3.50	$3.00	____dz.	_____
				
179 Perio Brush. Super-soft .007" bristles spaced for sulcular brushing techniques.	$3.50	$3.00	____dz.	_____

*Any combination totaling one gross or more.

†Please allow six weeks for delivery. Minimum children's order, two gross.

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Editorial

The main reason for my accepting the honour of guest-editing two Issues of the Journal is the unique opportunity to provoke the reader. Basically my character is peaceful in nature. This does not restrict controlled intellectual aggression, which among intelligent people has beneficial effects. I am a firm believer in the necessity of exchange of scientific developments that originate in various regions of the world. International cross-fertilization often has provocative potential and I will briefly try to explain its mechanism.

It is a common observation that new knowledge frequently grows into applicability in the country of its origin but may remain unnoticed in others. The reasons for this have not been established. Language barriers were perhaps important two decades ago but they are negligible today because of modern well organized translating and abstracting services.

Barriers may also be unconsciously created by nationalistic and autistic attitudes of scientists according to their specific environment. Leadership, superiority of a nation in some areas of biological sciences may be erroneously extrapolated to exist also in other research areas where he is personally engaged. A further explanation for conservative isolationism and "international inertia" may be that financial support of research mainly stems from national and less from international sources. "No man can be a patriot on an empty stomach". (W. C. Brann).

For me the most significant cause for the disregard of scientific achievements elsewhere is the geographical factor. Specific geographic behavioural patterns are imposed by the local history, culture, traditions and habits. In his habitat, the researcher is well familiar with his collaborators, his scientific methods, apparatus and much less with others.

Eventual modification of research goals involves overcoming personal inertia. Additional limitations arise because of the lack of means to invest in new research tools. For this reason, progress is directed to some extent by one's own spectrum of facilities. However, changes of attitudes and traditions can be brought about by provocations leading to conflicting situations which may, but not necessarily do, result in stimulation and intellectual fertilization.

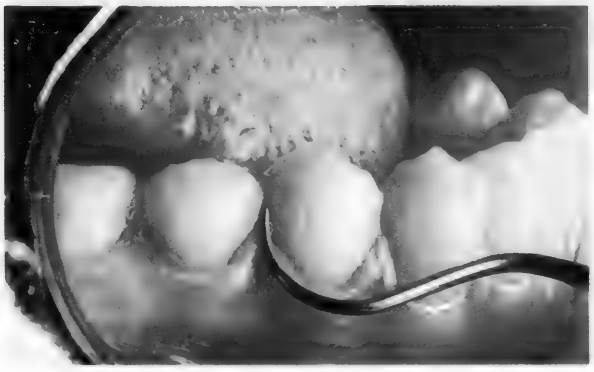
As Chairman of the Department of Cariology and Periodontology at the Dental School of the University of Zurich I was fortunate to be assisted by several staff members when preparing the contributions for the next two Issues. The first article by Imfeld and Mühlemann intends to familiarize the American reader with the scientific and political developments in Switzerland in the area of sugar substitution research. The aim is to protect the consumer from false claims by manufacturers of confections. The Swiss child knows whether he can indulge in candies, chewing gum and other sweets if they are labelled "safe for teeth". Such products do not critically acidify dental plaque.

The second contribution, "Prevention of Microleakage and the Achievement of Optimal Marginal Adaptation" is presented by Lüscher, Lutz, McDermott and Mühlemann. In several areas of Switzerland, the prevalence of dental caries and gingivitis has decreased spectacularly during the last 10 to 15 years. Public health measures supervized mainly by Th. Marthaler at the Department of Cariology and Periodontology of the Zurich Dental School are responsible for the decrease in oral disease. The incidence as well as the size of carious lesions has been reduced relevantly. New cavity preparation designs are necessary to minimize the destruction of sound dental tissue by classical cavity preparations such as for the treatment of initial interproximal caries. New cavity designs permit the use of composites even for class II restorations—but an additional 5 to 8 years are needed for a definite evaluation of these concepts. Non-destructive methods used in Zurich for the in vivo evaluation of the marginal seal are explained.

In the next Issue of the Journal the reader will be confronted with chemotherapy of plaque and gingivitis and with a new method to motivate for preventing oral disease.

H. R. Mühlemann
Zurich

Trident: a sugarless alternative



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Evaluation of Sugar Substitutes in Preventive Cariology

Th. Imfeld, Dr. Med Dent.* and H. R. Mühlemann, Prof. Dr. Med.†

Dental caries results from the interaction of plaque, fermentable carbohydrates, saliva and surface enamel deficient in fluoride. Freedom from caries can be achieved either by complete eradication of plaque or by the reduction of frequent intake of fermentable dietary saccharides. The incidence of dental carious lesions can also be reduced by 50 per cent with water fluoridation or a regular intake of fluoride tablets and regular use of fluoride containing dentifrices.

Only an estimated 20 to 25 per cent of the population will participate successfully in some plaque control program. This same oral hygiene-minded fraction of the population will also most often possess and adhere to an intelligent and disciplined attitude regarding consumption of fermentable carbohydrates. Preventive dentistry must be aware of the inadequate oral hygiene awareness of the majority of people and should therefore strive for and support the substitution of fermentable carbohydrates by nonfermentable sweets.

Approximately 30 per cent of the 140 g of sucrose consumed daily by the average Swiss citizen consist of confectionery: candies, sugar gelatins, jellies, marshmallows, meringues, ice creams, cocoa and soft drinks, chocolate, chewing gum and so on. These are sucrose containing products consumed primarily between meals and rather frequently during the day. Therefore, these should be given priority in the development of sucrose substitution programs.

The industry's search for sugar substitutes to be used in the manufacture of less- or noncariogenic confections has intensified in recent years. The claim that a sweet confection is *noncariogenic* or *less cariogenic* (hypocariogenic) can only be based on results from *clinical caries incidence studies*. Such investigations are very demanding, expensive, time consuming and sometimes difficult to perform because of obvious ethical considerations (control group). In Switzerland this problem has been managed satisfactorily by plaque pH-telemetry.

DEFINITIONS

The expressions "sugarless" (German: "zuckerfrei") and "safe for teeth" (German: "zahnschonend") have been defined by the Swiss Office of Health on December 10, 1968, and on January 22, 1969. "Sugarless" confections contain neither sucrose nor any other fermentable hexose: glucose, fructose, maltose, lactose, galactose etc. In the federal regulation the term "sugar" is not just used as a synonym of "sucrose" but in its true chemical sense including: (1) *Monosaccharides*: aldohexoses (glucose, d-mannose, d-galactose), ketohexoses (fructose, sorbose), aldopentose (arabinose, xylose, ribose). (2) *Disaccharides*: sucrose, lactose, maltose, and trehalose. (3) *Trisaccharides*: melitose, and (4) *Oligosaccharides* (e.g. triomaltose, tetramaltose, etc.).

Sugarless confections most often contain sugar substitutes. "Sugarless" does not automatically imply that a product is nonacidogenic in dental plaque. It may contain other fermentable carbohydrates, such as starch or other carbohydrate polymers. In other countries the term "sugarless" is synonymous to "without sucrose".

Confections "safe for teeth" are products which by fermentation during consumption and up to 30 minutes later do not lower the pH of interdental plaque below 5.7. This critical limit is arbitrary and valid only when assessing plaque-pH telemetrically, *i.e.* without disturbing the plaque structure and diffusion characteristics and without interference by the measuring method with normal salivary influences upon plaque. The critical

FIG. 1. Miniaturized pH-glass-electrode containing a FET-impedance transformer ready to be mounted into a removable partial prosthesis.

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† Dental Institute, University of Zurich, Head of the Dept. of Cariology and Periodontology, Plattenstrasse 11, CH-8028 Zurich.

pH-value of 5.7 in pH-telemetry corresponds to a pH of approx. 6.5 when making in vitro measurements with plaque samples removed from the teeth before and after the ingestion of carbohydrates to be tested (Methods of Frostell[7]). Sugar substitutes most often used for the manufacture of sweet confections "safe for teeth" are sugar alcohols such as nonacidogenic xylitol (pentitol), or slowly fermenting (hypo-acidogenic) sorbitol, mannitol, maltitol (hexitols) and LYCASIN® (= POLYSORB).

Acids formed in plaque from confections containing hypo-acidogenic hexitols can continuously be neutralized by the salivary bicarbonate buffer system, thus inhibiting a drop of plaque pH below 5.7. The role of salivary flow in plaque pH should not be underestimated and can only be adequately evaluated under in vivo conditions and using plaque pH-telemetry. Hypo-acidogenic confections increasing salivary flow particularly by *mechanical stimuli* (chewing, rough surface texture of a hard candy) or by *chemical actions* (citric acid, flavours, etc.) may in borderline cases, because of increased salivary buffer secretion, still be acceptable as "safe for teeth", or "not harmful for teeth", or "not damaging to teeth" by *plaque acid formation*.

It is assumed and highly probable that non-acidogenic or hypo-acidogenic (pH 5.7) carbohydrates are either noncariogenic or only slightly cariogenic. Xylitol, for instance, which is non-acidogenic in the telemetric pH-test[5] and in animal caries tests[5] has been shown in the clinical Turku Sugar Studies[9,18,21,26] to be noncariogenic, in contrast to fructose which increased the caries rate and which, in pH-telemetry, acidifies plaque into the "dangerous" enamel demineralizing area.

Swiss manufacturers are allowed to advertize their confections as being "safe for teeth", if they submit convincing pH-telemetric tests to the Swiss Office of Health. These tests are presently performed at this department. A list of chewing gums and candies that, as of 1975, may be labeled "safe for teeth" has been recently published.[27] Interestingly enough, out of the 13 confections, 8 products have been evaluated for foreign manufacturers in Denmark, Germany and the USA where a similar compulsory regulation for consumer protection does not exist.

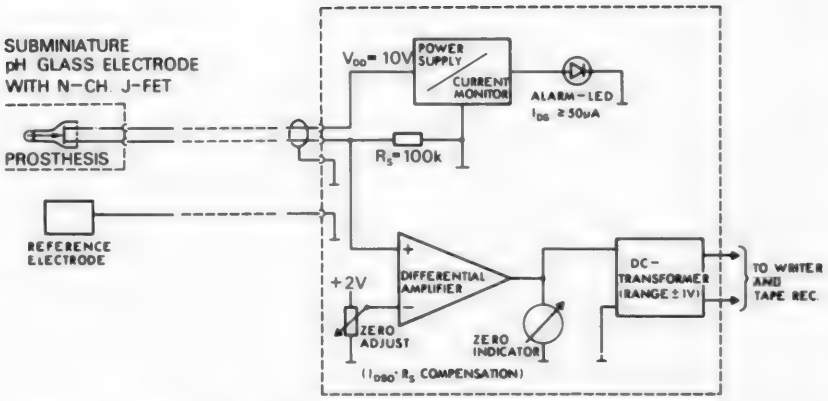

FIG. 2. Diagram of plaque-pH wire telemetry.

FIG. 3. Partial prosthesis used for multi-channel wire telemetry. The tip of a pH-electrode facing the distal surface of the right lower canine is clearly visible.

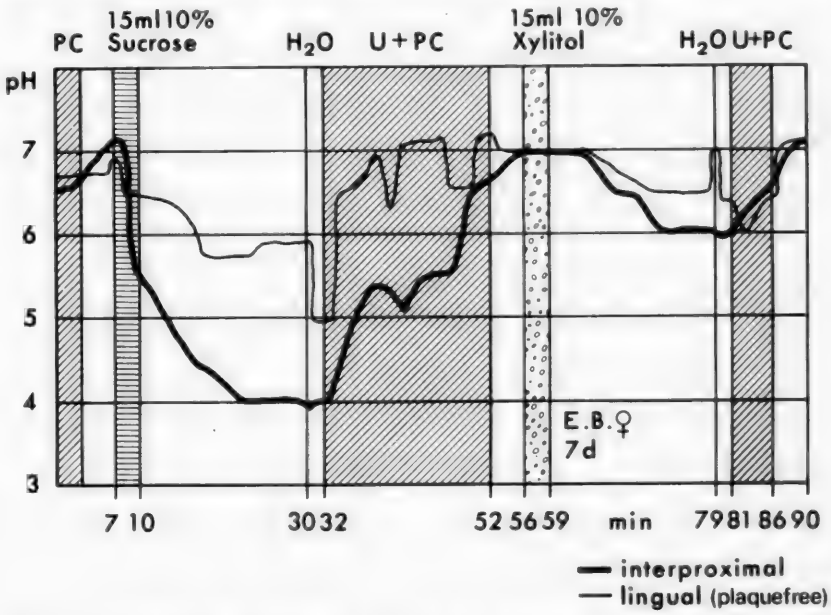

FIG. 4. Telemetrically recorded pH of 7-day old interproximal plaque and of mixed saliva in the lingual area of subject E.B. during and following treatments with 10 per cent aqueous rinsing solutions of sucrose and xylitol respectively. (PC) paraffin-chewing, (H_2O) water rinse, (U + PC) carbamide rinse and paraffin-chewing, (d) plaque age in days. Note the pronounced drop in plaque pH to a 4.0 level. In spite of previous stimulation of saliva by chewing, the pH of mixed saliva recorded on a clean lingual electrode also decreased indicating glycolytic activity by the total oral microflora. Rinsing with three per cent carbamide and paraffin-chewing restored pH-levels rapidly in mixed saliva; more slowly for plaque-pH. Xylitol was not fermented. The decrease of plaque-pH towards 6.0 was close to the initial fasting values and was probably partly due to sucrose not totally cleared from all oral areas.

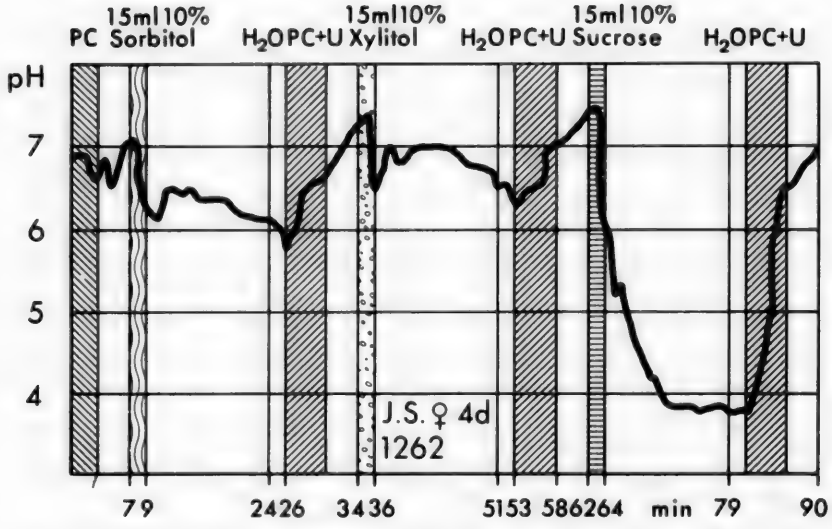

FIG. 5. Telemetrically recorded pH of 4-day old interdental plaque in subject J.S. during and following treatment with 10 per cent aqueous rinsing solutions of sorbitol, xylitol and sucrose respectively. (PC) paraffin-chewing, (PC + U) paraffin-chewing and carbamide rinse, (H_2O) water rinse, (d) age of plaque in days. The hypo-acidogenic rinse with sorbitol, and the nonacidogenic rinse with xylitol were both "safe for teeth" in contrast to the "harmful", very rapid and pronounced decrease of plaque-pH during and subsequent to the sucrose treatment. Xylitol is a pentitol, a hydrogenated xylulose which is a normal intermediate of the pentose phosphate pathway.[17,24,29] Xylitol is readily metabolized by mammalian cells but not by cariogenic bacteria.[20] It is sweeter than sucrose. While being non-acidogenic under laboratory conditions[8,15] and in plaque pH-telemetry[5,16] its noncariogenicity has been shown by the Turku Sugar Studies.[9,18,21,26] Disadvantages of xylitol are its hygroscopy, the production of diarrhoea and high manufacturing costs. Sorbitol is a hydrogenated glucose.[11,23] In nature it is found in apples, pears, cherries etc. The fermentability of sorbitol by oral bacteria in man has been shown to be slow.[3,22] Sorbitol is "safe for teeth" when used as a sugar substitute in lozenges and in chewing gums.[27] It is, however, difficult to manufacture sorbitol-containing boiled candies.

PLAQUE-pH-TELEMETRY

Telemetry of plaque-pH from the interdental area using miniaturized glass-pH-electrodes was first announced in 1965 and 1966 by Graf and Mühlemann.[13,14] During the last 10 years telemetry has become an important method for assessing pH-changes of the oral fluid and of dental plaque in response to various foods and drugs. This department has extensively reported on such pH-measurements[4,12,24,27].

Bio-telemetry means direct and continuous measurement of biological phaenomena in fairly inaccessible areas, the measuring method not interfering with the processes to be evaluated. The data may be transmitted to the laboratory recording equipment by wireless transmission (radio-telemetry). Transmission by wire is possible and more economical for interdental pH-telemetry when testing rinsing solutions, candies and lozenges to be dissolved in the oral cavity. Wire telemetry can, with certain precautions, also be used for chewing gum studies. Fibrous food or desintegrating crackers etc. interfering with the functional stability of the measuring system can be wrapped in gauze and chewed without disturbing the wire connection to the recording equipment. The telemetric curves presented have been traced with a multi-channel telemetric system described in 1974.[2]

A recent development for minimizing insulation problems is the use of miniaturized pH-glass-electrodes containing a FET-impedance transformer (Fig. 1). The reference electrode formerly built into the prosthesis is now a skin electrode fastened with a rubberband to the arm of the subject. A schematic outline of the electronic system is given in Figure 2. The pH-sensor is located in the proximal surface of an extracted tooth built into the prosthesis next to the surface of an adjacent natural tooth (Fig. 3).

Following the insertion of the prosthesis, plaque will form interdentally and over the tip of the glass electrode. The volunteer refrains from oral hygiene procedures for 6 to 8 days. The removable prosthesis with the glass electrode is then cleaned again. At present 10 adults regularly participate in the pH-telemetry program (one to three subjects per day), pH-telemetry in children has not been attempted because of technical and organizational difficulties.

pH changes resulting from acids formed in interdental plaque when exposed to fermentable carbohydrates can be recorded with good reproducibility when experimenting with 3 to 7 day old bacterial deposits. pH changes of mixed saliva by dietary acids, such as citric acid additives to candies, can also be measured with the same interdental electrode if clean and not covered by plaque.

In some prostheses a second pH glass electrode was mounted into the lingual aspect of the prosthesis saddle. Thus, using a prosthesis with both a plaque covered interdental and plaque-free lingual sensor, it is possible to record simultaneously not only (a) acid formed by interdental plaque covering the sensor, but also (b) acid formed by the total oral microflora (dental plaques and microorganisms on the dorsum of the tongue etc.) which lowers salivary pH at the site of the lingual sensor, (c) dietary acid contacting the clean electrode directly during ingestion and subsequently, mixed with saliva, being associated with a gradual increase in pH.

The interest of European candy manufacturers has especially been drawn to sorbitol, xylitol, and their combinations and more recently to sorbose. The choice of the sugar substitute depends on: (1) the availability of acceptable artificial sweeteners (cyclamates in the case of sorbitol and LYCASIN), (2) the type of confection to be manufactured (hard candy, soft candy, lozenge, chewing gum, and chocolate. A few typical telemetric plaque pH recordings will be presented in order to familiarize the reader with the possibilities of continuous in vivo pH monitoring in preventive dentistry.

TELEMETRIC pH-RECORDINGS

In the following pH telemetry sessions, various sugar substitutes such as xylitol, sorbitol, LYCASIN 80/55 and the ketohexose L-sorbose were administered to the volunteers either as 10 per cent aqueous rinsing solutions or as existing ingredients in marketed products such as chewing gums (xylitol), toffies (sorbitol) and hard candies

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*Some dental authorities now recommend 0.25 mg. F daily under age 2.

[1]*Accepted Dental Therapeutics:* 241, 1973-1974. [2]Aasenden, R., and Peebles, T.C.: Effects of Fluoride Supplementation from Birth on Human Deciduous and Permanent Teeth, *Archs Oral Biol* 19:321, 1974. [3]Mellberg, J.R., Nicholson, C.R., and Law, F.E.: Fluoride Concentrations in Deciduous Tooth Enamel of Children Chewing Sodium Fluoride Tablets, *J. Dent Res* 51:551, 1972.

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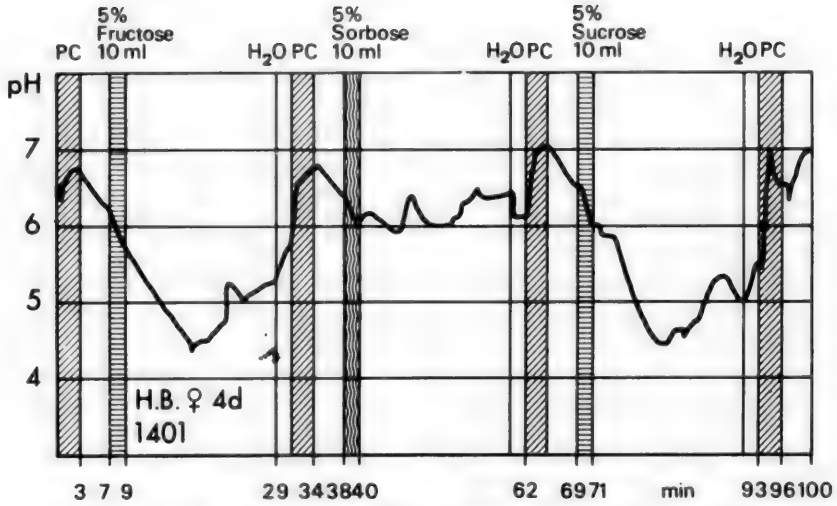

FIG. 6A. Telemetrically recorded pH of 4-day old interdental plaque in subject H.B. during and following treatment with 5 per cent aqueous rinsing solutions of fructose, L-sorbose and sucrose respectively. (PC) paraffin-chewing, (H_2O) water rinse, (d) age of plaque, days. Sorbose is "safe for teeth". L-sorbose is a ketohexose stereo-isomeric to D-fructose. It is produced from sorbitol by dehydrogenation.[1,19] The nonfermentability of sorbose for plaque microorganisms was reported in 1930[10] and was later confirmed telemetrically.[25] Sorbose is a reducing sugar and in Switzerland may not be incorporated into sweet confections labeled "sugarless". Since, however, it is only slowly fermented in human plaque, it is a tempting alternative for the manufacture of confections "safe for teeth". Also it has many similarities to sucrose (crystalline, nonhygroscopic etc.). Its sweetness is greater than that of sorbitol, mannitol, and some LYCASINS. In contrast to the polyols sorbose caramelizes at high temperature. It can be used for the manufacture of hard candies, caramels, lozenges, chewing gums, chocolates, biscuits, sweet drinks, marmalades, ice creams etc. Sorbose can also serve as a crystalline glaze in jellies and icings.

LYCASIN 80/55). Ten per cent sucrose solutions served as positive controls to demonstrate proper functioning of the telemetric measuring system. In other cases, chocolate containing sugar candies served as positive controls (Fig. 11). The effects of the "sweets" on interdental plaque pH is visualized in figures 4–11. Details of the treatment sequences are explained in the legends.

At the beginning and end of each session, as well as between treatments, neutralization of acidified plaque was achieved by stimulating salivary flow with chewing of neutral paraffin. If very low plaque pH values were attained by glycolysis, rinsing with a 3 per cent carbamide* solution greatly enhanced the neutralization of plaque acids by intraplaque ammonia formation. Carbamide appeared to be cleared very rapidly, however, to be certain of its removal, a paraffin-chewing phase was included which in every case resulted in an elevation of plaque pH values between 6.7 and 7.5. The lowest recorded pH-values during and following the ingestion of the above mentioned sugar substitutes never reached the critical pH-value (5.3–5.5), *i.e.* the range where enamel dissolution probably is initiated ("dangerous, harmful, damaging pH-zone"). This "scientific" pH range of 5.3 to 5.5 should not be confused with the pH level of 5.7 which is critical for the official designation "safe for teeth" and which includes a safety range.

DISCUSSION

In all telemetric sessions, the 10 per cent sucrose rinses and the sucking of sucrose containing candies confirmed a good functioning of the measuring equipment and of plaque metabolism. The pH consistently dropped to a level between 3.75 and 4.50.

Chewing gums "safe for teeth" regularly increased the pH over fasting values. These high pH values were due to the lack of fermentable carbohydrates and the increased buffering capacity of stimulated saliva. Chewing

* E. Merck, Darmstadt, Germany.

FIG. 6B. Chemistry of D-fructose (left) and L-sorbose (right) mentioned in figure 6A.

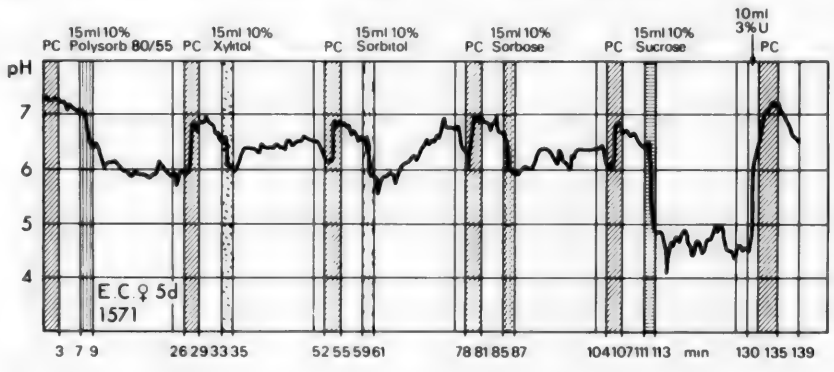

FIG. 7. Telemetrically recorded pH of 5-day old interdental plaque in subject E.C. during and following treatments with 10 per cent aqueous solutions of LYCASIN [= POLYSORB] 80/55, xylitol, sorbitol, sorbose and sucrose. (PC) paraffin-chewing, (U) carbamide rinse, (d) days, age of plaque. LYCASIN is a syrup mixture of hydrolyzed and hydrogenated potato starch. There are different types of LYCASIN: 80/25, 80/33, 80/45 and 80/55. "80" designates the dry weight percentage of the syrups. The second number, *e.g.* 55 expresses the percent content of sorbitol and maltitol. 45 per cent are hydrogenated dextrins. LYCASIN 80/55 has been shown to be "safe for teeth" under certain conditions,[6] but not 80/45, 80/33 and 80/25. Unfortunately, the degree of hydrolysis and hydrogenation of starch which is negatively correlated with the content of fermentable glucose, maltose and triomaltose, varies slightly from batch to batch. LYCASIN-containing products, therefore, often need acid-neutralizing additives such as di-ammoniumphosphate. LYCASIN 80/55 has successfully been incorporated into candies although there are technical problems due to its hygroscopy.

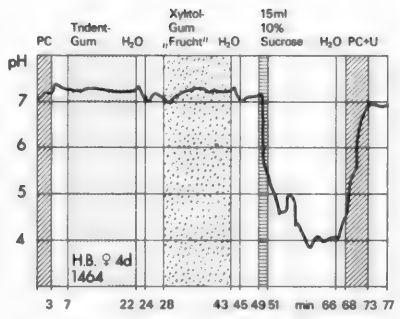

FIG. 8. Telemetrically recorded pH of 4-day old interdental plaque in subject H.B. chewing TRIDENT® containing a mixture of sorbitol and mannitol, and a gum with xylitol and "Frucht" = fruit flavor respectively. A 10 per cent aqueous solution of sucrose served as positive control. (PC) paraffin-chewing, (H_2O) water rinse, (U) carbamide rinse, (d) age of plaque, days. Sorbitol- and xylitol-containing sweets and gums are "safe for teeth" if they do not contain other fermentable additives as shown in Fig. 9. Sugar containing chewing gums have been shown to be not "safe for teeth".[25]

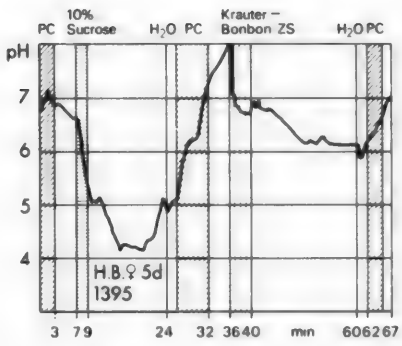

FIG. 10. Telemetrically recorded pH of 5-day old interdental plaque in subject H.B. during and following treatment with a 10 per cent aqueous rinsing solution of sucrose and arabic gum containing sorbitol respectively. (PC) paraffin-chewing, (H_2O) water rinse, (KRAUTERBONBON ZS) = sorbitol containing arabic gum, (d) age of plaque in days. The chewable arabic gum containing sorbitol was "safe for teeth".

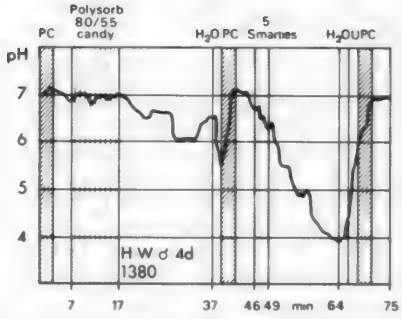

FIG. 11. Telemetrically recorded pH of 4 day old interdental plaque in subject H.W. during and following treatment with a candy containing LYCASIN [POLYSORB] 80/55 and with 5 small chocolate containing sugar candies SMARTIES®.* (PC) paraffin-chewing, (U) carbamide rinse, (H_2O) water rinse, (d) age of plaque, days. LYCASIN 80/55 candies (batch 52553) were "safe for teeth". SMARTIES® may be smart for the taste buds on the tongue—less however for apatite crystals.

of gums "safe for teeth" subsequent to sucrose intake has been shown to rapidly neutralize plaque acids.[27]

In contrast to chewing gums, candies "safe for teeth" do not have pH raising effects probably because of less pronounced salivary stimulation. However, such confections never acidified plaque below the critical pH value of 5.5, thus representing an important contribution to preventive cariology.

The variability in chemical and physical characteristics of the different sucrose substitutes discussed determines their appropriate use in the confectionery industry. Further refinements in manufacturing will have to solve the technical problems related to excessive hygroscopy of the polyols. Future research should also concentrate on the avoidance of their side-effects such as diarrhoea. The reduction of the caloric intake through sucrose substitutes with respect to the prevention of obesity, vascular and cardiac disease, diabetes and other illnesses is accentuating their great importance. This new line of research is a future task both for preventive medicine and preventive dentistry.

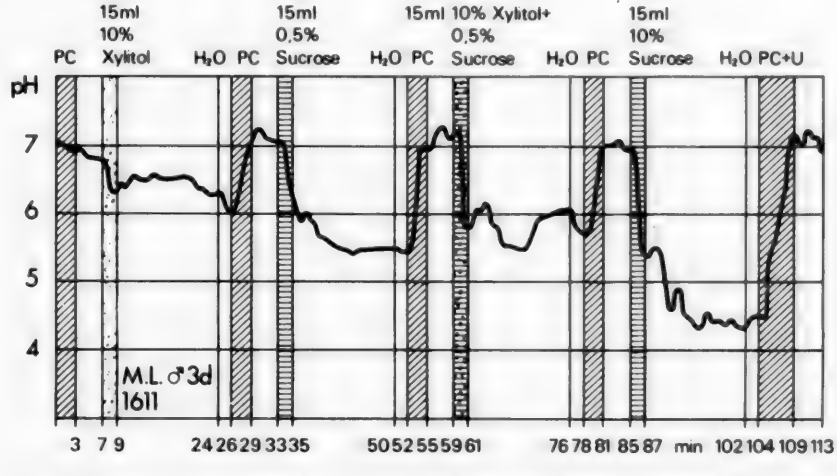

FIG. 9. Telemetrically recorded pH of 3-day old interdental plaque in subject M.L. during and following treatment with aqueous rinsing solutions of 10 per cent xylitol, 0.5 per cent sucrose, 10 per cent xylitol *with* 0.5 per cent sucrose, and 10 per cent sucrose respectively. Note that the small amount of sucrose contained in 15 ml of a 0.5 per cent aqueous solution acidifies the plaque into the "enamel damaging pH-zone" of 5.4. The same small amount of sucrose added to a 10 per cent aqueous xylitol solution has the same effect. This shows that even extremely minimal amounts of fermentable carbohydrates, contained in additives (colors or flavoring ingredients) of a confectionery, can completely destroy its potential safety for teeth.

* SMARTIES,® Rowntree Mackintosh Ltd., York, Great Britain.

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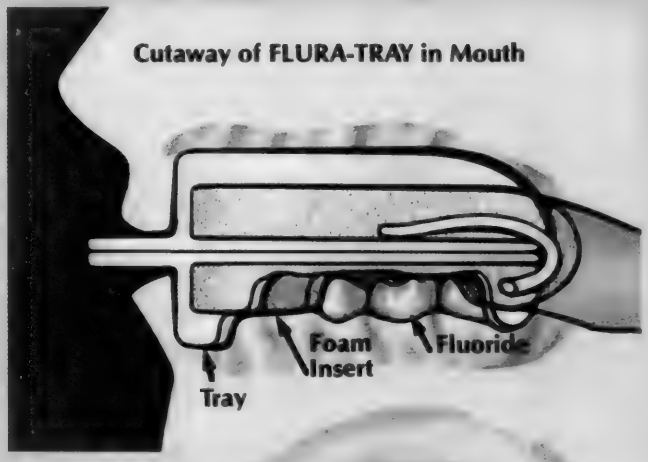

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The Prevention of Microleakage and Achievement of Optimal Marginal Adaptation

Bernard Lüescher, D.M.D.,* Felix Lutz, M.D., D.M.D.,* Terry McDermott, D.D.S.,** and Hans R. Mühlemann, M.D., D.M.D.†

Despite all endeavours in the field of restorative dentistry, there exists to date no ideal restorative material. The physical properties of present materials as well as conventional "extension for prevention" principles demand that considerable sound tooth substance be sacrificed to provide sufficient retention and bulk to the restoration. In this sense, operative dentistry can be considered destructive in nature.[26]

Most restorations are not stabile in form and volume, either they exhibit a certain flow or creep or the abrasion resistance is unsatisfactory.[8,25,27] Furthermore, with time, no restorative is leak-proof. There exist or develope microfissures between the restoration and hard tissue inducing percolation. As a consequence, penetration of microorganisms may occur, initiating chemical, mechanical, or microbial destructive processes, as well as, chronic hypersensitivity of dentin, fractures of enamel margins, discolorations and secondary caries. The width of these fissures is variable depending upon material, cavity preparation form, extension and age of the restoration and insertion technique.[2,5,10,18,24]

The last few years have witnessed an increasingly growing interest in composite materials. However, cavity preparation principles for these materials have remained to a large extent the same as those for amalgam although the physical properties of the two materials differ significantly.[8,25]

It has recently become possible to effect a micromechanical bonding of composite material to conditioned enamel. Theoretically such bonding, may result in better adaptation of restorative material to tooth substance and prevention of microleakage along the entirety of the cavity margin. This is however not the case in conventional class II cavity restorations, using composite material and etching techniques.[15,20] The forces of polymerisation shrinkage (1,5–2,1 v/v%) of composite resins exceed the mechanical bonding forces existing between restorative and etched enamel with subsequent damage to the potential bond.[2,3,14,18]

The application of a low viscosity sealant to the etched enamel prior to

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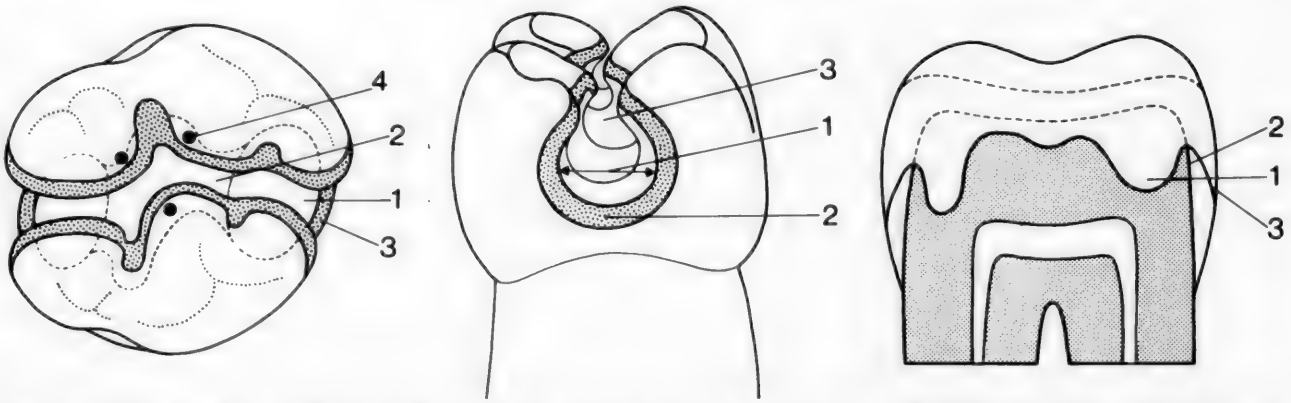


FIG. 1a–c (a Left). Class II, adhesive cavity preparation, occlusal view: 1 proximal dentin cavity, 2 occlusal dentin cavity, 3 bevelled enamel, 4 occlusal centric contacts (b Center), proximal view: 1 proximal enamel cavity extension, 2 bevelled enamel, 3 dentin cavity. (c Right), mesiodistal view: 1 proximal dentin cavity, 2 dentin-enamel shoulder, 3 bevelled enamel.

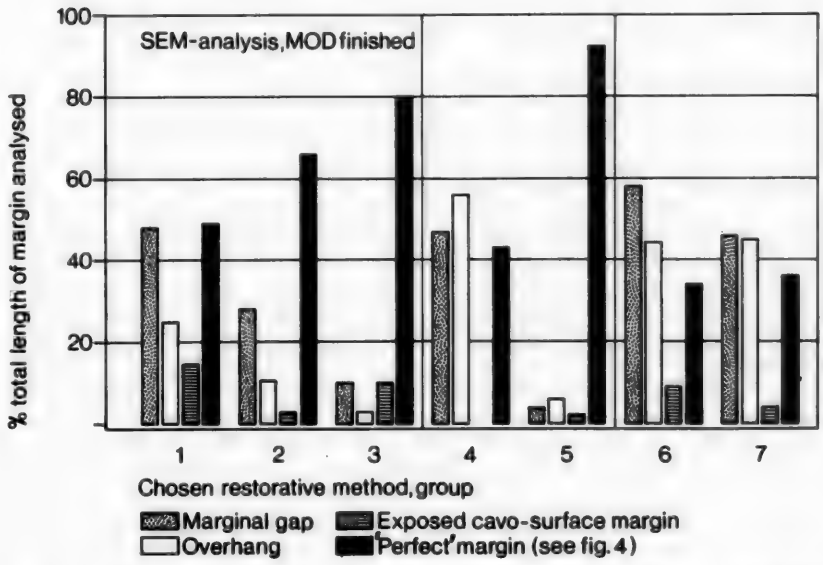


FIG. 2a. Marginal adaptation as a function of enamel etching, sealing, cavity shape and/or priming. The percentage of examined cavity margin exhibiting gap, composite overhang, exposed cavosurface areas, and "perfect" adaptation. (see fig. 4). Group 1: conventional cavity preparation, standard-composite (Adaptic®, Concise®); group 2: conventional cavity preparation, etching, standard-composite; group 3: conventional cavity preparation, etching, sealing, standard-composite; group 4: adhesive preparation, etching, standard-composite; group 5: adhesive preparation, etching, sealing, standard-composite; group 6: adhesive preparation, etching, composite (Cosmic®); group 7: adhesive preparation, etching, priming, composite.

bulk placement of the resin into a conventional BLACK preparation has not reduced microleakage. This realization plus the fact that the retentive properties of the restorations are only marginally improved with the use of the sealant, has led many authors to question its necessity in composite systems.[1,6,7,9,11–13,15,18,20,23]

Several recent studies undertaken at this Institute have attempted to significantly reduce or actually prevent microleakage and to improve marginal adaptation. To the end, new cavity preparation principles and application techniques have been combined with different restorative materials. The type class II cavity was chosen because it distinctly exemplifies the problems with which we are concerned. The preparation normally features a relatively large volume and encompasses probably the widest extention of difficult to assess margins; it can be considered one of the most difficult restoration to perform. The adhesive restorations to be described were subjected to dye-penetration tests and to scanning electron microscopic examinations of replicas to evaluate micro-leakage and the quality of marginal adaptation.* This report

* The marginal integrity of a restoration encompasses, in our scope, two separate yet interrelated micromorphological characteristics. On the one hand, the impermeability of the margins to microleakage as measured in *in vitro* as well as *in vivo* dye penetration tests, and on the other hand, the marginal adaptation of the restorative material to peripheral tooth substance evaluated by replica examination with the scanning electron microscope. For example, it has been found that a restoration may exhibit little or no microleakage in penetration tests, however under the scanning electron microscope, gaps or fissures may be noticed which may become later clinically evident as stained margins. The opposite has also been observed: under SEM examinations, the marginal adaptation may appear excellent, but dye penetration tests reveal microleakage. Therefore both terms are meaningful in describing marginal "seal".

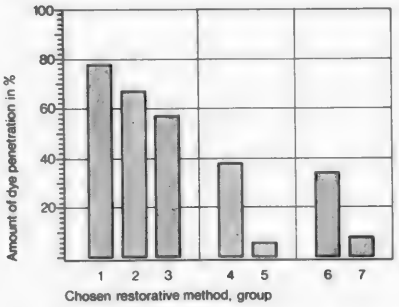


FIG. 2b. Dye penetration along cervical cavity/restoration interface after a 20h, exposure to basic fuchsin as a function of enamel etching, sealing, cavity shape and/or priming. Scores: 0%: no penetration, 20%: penetration not exceeding outer half of enamel thickness, 40%: not exceeding cervical dento-enamel junction, 60%: penetration reaching middle of cervical wall, 80%: penetration almost reaching axial wall, 100%: penetration along axial wall, Group 1–7 see fig. 2a.

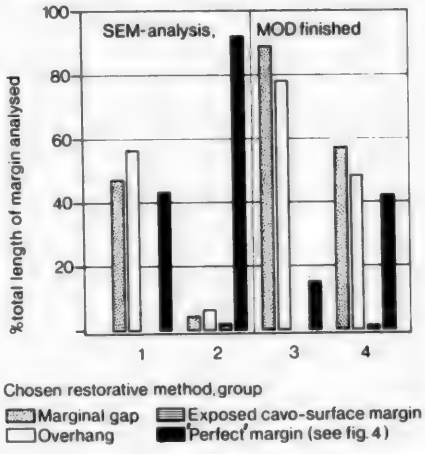


FIG. 3a. Marginal adaptation with standard-composite systems, a thixotropic composite and syringe system composites. Group 1: adhesive preparation, etching, standard-composite; group 2: adhesive preparation, etching, sealing, standard-composite; group 3: adhesive preparation, etching, thixotropic composite (ZKP-A-5); group 4: adhesive preparation, etching, syringe system composite (Concise®, Compocap-S®).

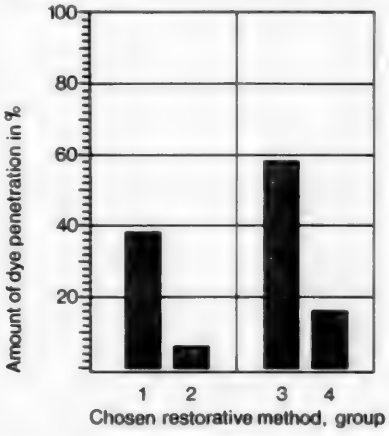
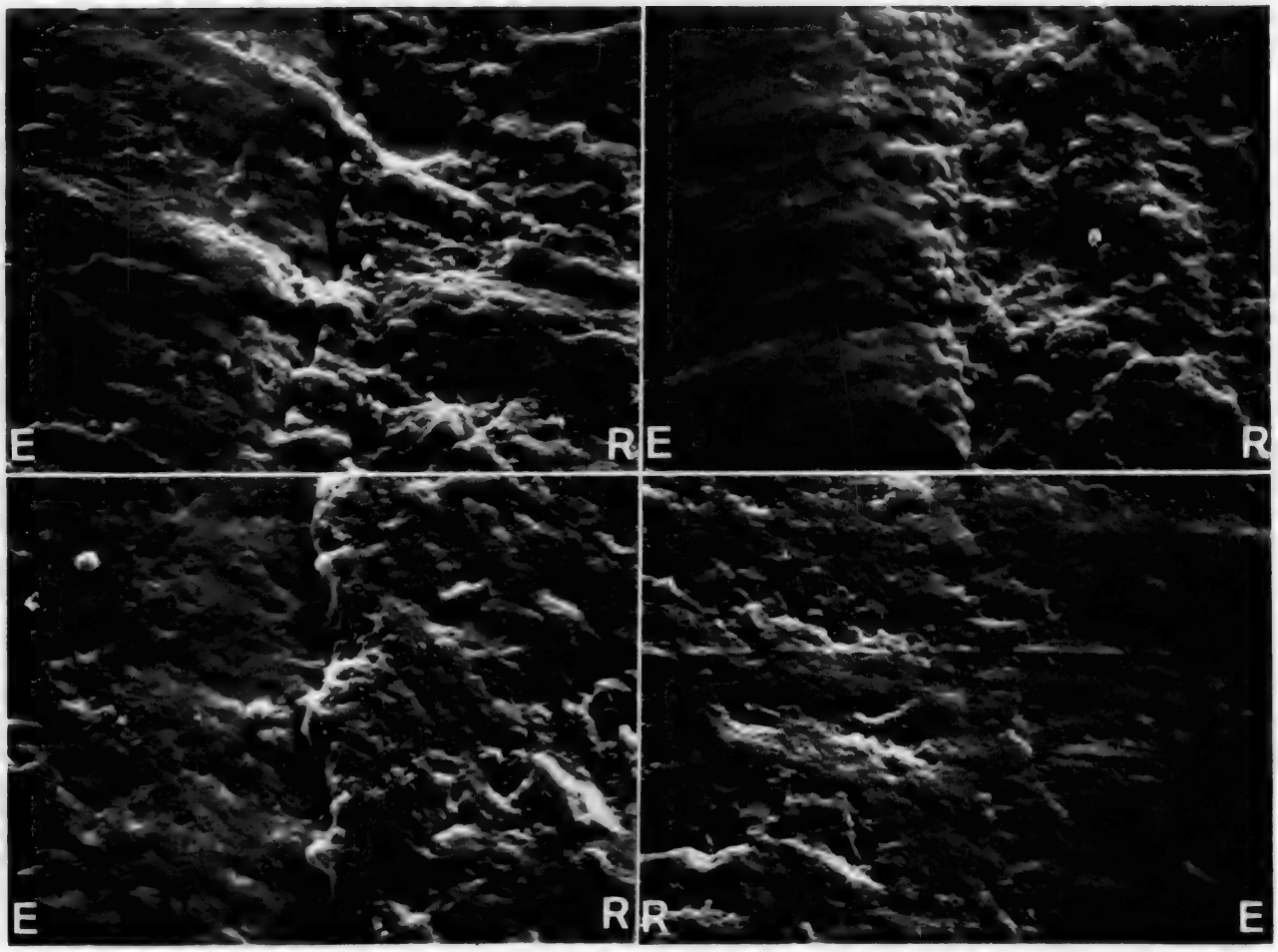


FIG. 3b. Dye penetration along cavity/restoration interface after a 20h exposition to basic fuchsin with standard-composite systems, a thixotropic composite and syringe system composites. Scores see fig. 2b; group 1–4 (see fig. 3a).



FIGS. 4a–d. (a top left) Marginal gap (SEM), magnification 560×, E = enamel, R = restorative material. (b top right) Exposed cavo-surface margin (as a result of underfilling), magnification 560×. (c bottom left) Overhang, magnification 560×. (d bottom right) "Perfect" margin, magnification 560×.

will summarize the results of these studies.[15,16,18–22,28]

CAVITY PREPARATION

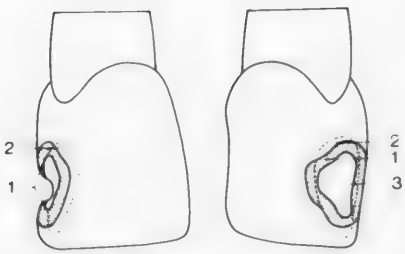
It is generally recognized that if composite restorative materials are to be used in class II restorations, the cavity preparation itself should be conservative. The conventional BLACK preparation is for various reasons not suitable: one reason is its disproportionate volume. Since polymerisation shrinkage increases with volume, these forces will draw the restorative away from the peripheral enamel walls resulting in microleakage and poor marginal adaptation.[15,20] The new MOD cavity design has been developed and described by LUTZ *et al.* 1974[17] and 1976[18,20] is characterized by a relatively conservative round or ovoid proximal "box", an occlusal preparation which can be best described as an extension of a fissure sealing procedure, and significant areas of bevelled enamel (fig. 1). This preparation saves a considerable amount of sound tooth substance and improves marginal integrity when using composite restorative materials in class II cavities[15,20]; figs. 2a and b).

Table 1. Quality of proximal marginal adaptation in % total length of margin analysed of conventionally prepared and filled MOD cavities as a function of insertion method.

	Marginal adaptation	
Insertion/compression method	"Perfect" margin (%) (see fig. 4)	Imperfect margin (%) (marginal gap and/or overhang and/or exposed cavo-surface margin; see fig. 4)
spatula	15	85
cotton pellets	27	73
polyurethane-foil and digital compression	49	51

USE OF SEALANTS

The use of a sealant prior to the insertion of the composite restorative



FIGS. 5a and b. Class III, adhesive cavity preparation, (left) labial view: 1 small extension of the cavity to the labial surface, 2 cavity outline (only caries removed). (right) lingual view: 1 bevelled enamel, 2 unsupported enamel, 3 entry of cavity.

is controversial. The tensile adhesion of most brands of materials to etched enamel is, for the most part, sufficient regardless of whether a sealant is applied or not. However, it has been shown that marginal adaptation and especially microleakage of composite resin restorations are significantly and positively influenced by prior application of the sealant[15,18,20,28] (figs. 2a and b).

PRIMING

One of the composite restorative materials examined in the studies[15,20] utilizes a N-Phenyl-Glycidyl-Glycidyl-Methacrylate primer (NPG-GMA) instead of a low viscosity sealant of the BOWEN diacrylate type. Primers are coupling agents or surface active comonomers. They contain polar groups which are said to chelate with surface calcium atoms of mineralized tissues.[4] In addition they contain radicals that copolymerize with the resin systems of the restorative material. There is little agreement in the literature as to their effectiveness. In the present studies, dye penetration was markedly reduced when the primer was applied before the insertion of Cosmic®,* On the other hand priming seemed to have no influence upon marginal adaptation[16,18,21] (figs. 2a and b).

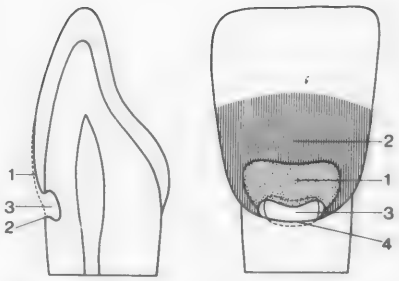
INSERTION OF RESTORATIVE MATERIAL

In one study,[15] the influence of different insertion and condensation techniques upon the quality of marginal seal was investigated. The results showed an improved adaptation when the restorative material, isolated by a polycarbonate foil, was digitally compressend until final set (Table 1).

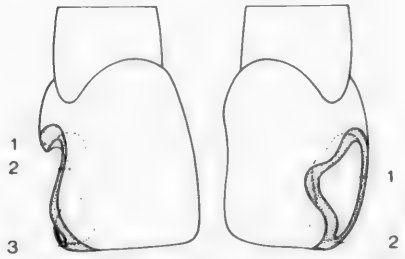
COMPOSITE MATERIALS AND RESULTS

Numerous brands of composite resins were utilized. One study[15] examined relatively older or standard restorative materials, while more recently available products (Table 2) were tested later.[16,21,22] One of the standard brands, however, was coevaluated in every test as a control or baseline material. The acid etch technique was applied with all resin systems; pretreatment with low viscosity sealant was carried out when normally included in the individual resin system. Two composite-sealer systems (Adaptic®**); (Concise®†) showed consistently superior marginal integrity when compared with the resin systems employing no sealant (Epoxydent®)‡, Restodent®)‡. The former were also superior to a system utilizing a primer instead of a sealant (Cosmic®). Two other presently available systems with low viscosity sealants (Nimetic®)§; GC's Epolite 100/Epobond®)¶ yielded less than favourable results.

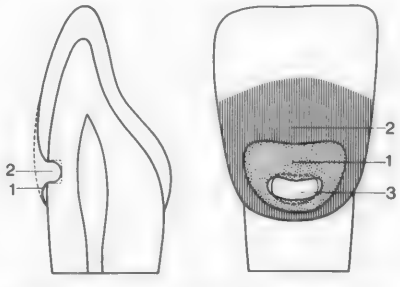
Examined also was one product (ZKP-A-5®)‖ said to exhibit certain thixotropic properties,* thus eliminat-



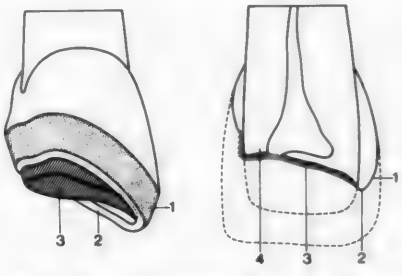
FIGS. 5g and h. Class V, cavo-surface margin in enamel and dentin adhesive cavity preparation, (left) cross section: 1 bevelled enamel, 2 conventionally finished cavo-surface margin within dentin, 3 modified dentin cavity (with retention). (right) labial view: 1 bevelled enamel, 2 prophylactically sealed labial surface, 3 modified dentin cavity, 4 conventionally finished cavo-surface margin.



FIGS. 5c and d. Class IV, adhesive cavity preparation, (left) labial view: 1 bevelled enamel, 2 cavity outline (only caries removed), 3 unsupported, conserved incisal enamel. (right) lingual view: 1 entry of cavity with lingual access, 2 bevelled enamel.



FIGS. 5e and f. Class V, cavo-surface margin entirely in enamel, adhesive cavity preparation (left) cross section: 1 bevelled enamel, 2 dentin cavity. (right) labial view: 1 extensively bevelled enamel, 2 prophylactically sealed labial surface, 3 dentin cavity.



FIGS. 5i and j. Fractured anterior teeth, adhesive cavity preparation, (left) labial view: 1 bevelled enamel, 2 fractured enamel surface, 3 dentin covered by a cavity base. (right) axial section: 1 bevelled enamel, 2 fractured enamel surface, 3 pulp dressing and cavity base, 4 dentin.

* De Trey GmbH, Wiesbaden, Germany.
** Johnson & Johnson, East Windsor, New Jersey, USA.
† 3M Company, St. Paul, Minnesota, USA
‡ Lee Pharmaceuticals, South El Monte, California, USA
§ ESPE GmbH, Seefeld, Oberbayern, Germany
¶ GC International Corp., Tokyo, Japan
‖ Laboratories of the Dental Institute of Zurich, Switzerland.
* Thixotropy—the property, exhibited by certain polymers, of changing from a solid to a more fluid state when disturbed (e.g. mechanical pressure from a spatula) and then reverting again to solid state following removal of the mechanical influence.

Table 2. List of composite systems used in *in vitro* conventional and adhesive MOD-restorations.

"Standard"-composite-system (phosphoric acid + sealer + composite)	Adaptic® + Adaptic Bonding Agent® Concise® + Concise Enamel Bond®
Carvable class II composite	Epoxydent®
Acid etch technique composite (phosphoric acid + composite)	Restodent®
Acid etch technique composite with primer	Cosmic® + Cosmic Bond® (primer)
Thixotropic composite	ZKP-A-5
Composite system (phosphoric acid + sealer + composite)	Nimetic® + Nimetic Bond® GC's Epolyte + GC's Epobond
Syringe-system-composite	Concise®-syringe-system-composite Compocap-S®

ing the necessity of the sealer pretreatment. The results obtained from this study,[22] however, revealed that this system was less effective in improving marginal adaptation than one utilizing a sealant-composite-resin combination (figs. 3a and b).

Similar conclusions were made also after the examination of two syringe system composite materials (Compocap-S®;*** Concise Syringe System Composite®).† Since the materials are injected with the syringe, they must have a somewhat lower viscosity than manually mixed resins. Both contain more low-viscous diluents and one less inorganic filler. It was theorized that because of their lower viscosity, no sealant would be necessary. However, with respect to microleakage and especially to marginal adaptation, findings were not encouraging (figs. 3a and b).

CONCLUSION

Observations from these studies have resulted in the formulation of certain criteria which should be adhered to if one is to reduce microleakage and achieve the best marginal adaptation possible from composite-resin restorative material. These are as follows: (1) adherence to the principles of adhesive cavity preparation; *i.e.* conservative preparations exhibiting rounded line angles and margins, and extensive areas of bevelled enamel (figs. 1, 5). (2) etching of enamel margins with acid. (3) application of a low viscosity sealant of the BOWEN diacrylate type prior to the insertion of the restorative. (4) insertion of suitable composite material and compression until final set.

It is of course mandatory that the operation field be kept absolutely free from moisture. The use of rubber dam, well fitting matrices and adequate wedging are to this end indispensable. To help counteract polymerisation shrinkage and subsequent formation of marginal gap or fissure, a load (finger pressure + 5 μm polycarbonate foil) should be exerted upon the material until final set.

Recent clinical studies[19,28] have substantiated these *in vitro* tests. Class III, IV and V type as well as fractured anterior teeth adhesive restorations were placed adhering to the above mentioned principles (fig. 5). Intra-oral dye penetration tests and replica examination with SEM immediately following insertion, 30 days, 120 days,[28] and finally 1¼ years postoperatively revealed insignificant microleakage and excellent marginal adaptation.[19]

It is important to bear in mind that physical properties of composite materials demand, that the volume of the restoration be kept minimal if marginal integrity is to be maintained. The indications for these materials in class II type restorative treatment is limited. The described class II adhesive restoration has been developed, one might say, as an extension of the measures in preventive dentistry. In the presence of initial proximal carious enamel lesions in children participating in a successful preventive dental program, this treatment method is indicated. Sound tooth structure can be conserved, the peripheral area of restored, etched, and sealed enamel may serve as an inherent "extension for prevention", and a marginal seal exhibiting excellent marginal adaptation and resistance to microleakage can be achieved.

*** Ivoclar AG, Schaan, Liechtenstein

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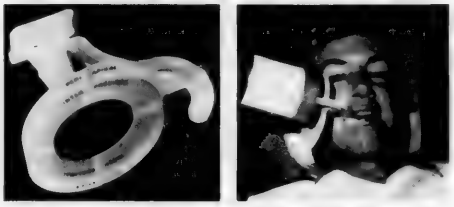

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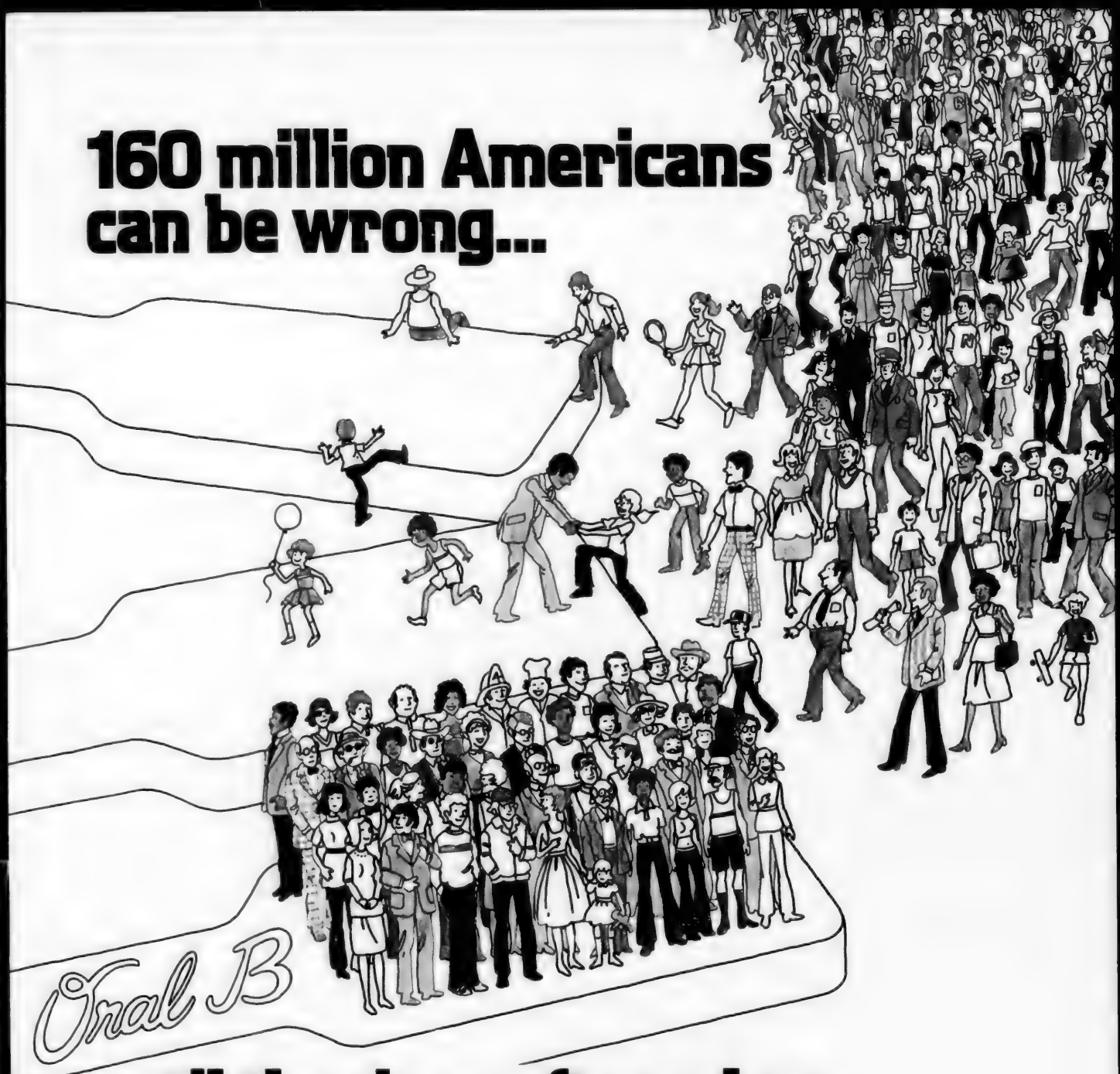

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The Prevention of Child Behavior Problems in the Dental Office

A Humanistic Approach†

Stanley R. Korf, D.D.S., F.A.C.D.*

The fears and anxieties of young children toward dentistry are not innate; they are learned. The genesis of unfavorable behavior in the dental office lies in the child's poor early exposure to dental matters. Such harmful initiation may be direct—pertaining to actual trauma or mistreatment in the dental office, or it may be indirect—the result of frightening comments made by other children and adults, or by negative attitudes of parents. Whether the fears and anxieties are perceived by the dentist and his staff as realistic or not is less important than recognizing the fact that they are indeed realistic to the young child.

Direct anxiety can usually be overcome fairly quickly and easily (unless it is of long standing or brutally severe) with gentleness, patience, cheerfulness and total honesty by the dentist and dental staff. Indirect anxiety is more pernicious and harder to deal with because it is not based on reality or rationality.

Wouldn't it be much better and easier for the dentist, working with the parent, to prevent apprehensions and anxieties of the child before they have a chance to begin to solidify? Of course it would, and the happy fact is that most of these worries and dreads can either be completely prevented, greatly minimized or soon eliminated if the child is introduced early enough to the dental situation. Early here means between the ages of 2½ and 3. I am in mild disagreement with some practitioners who suggest routine visits before the age of two. Most children this age are not yet ready for even simple explanations of what is to take place, and most children under the age of two seldom possess even the meager social background necessary for positive interaction with strange adults and places.

No matter what the age of the child, an empathetic practitioner with basic knowledge and understanding of the whys and wherefores of child behavior, who best understands himself and who has a goodly share of plain common sense will be able to consistently work wonders with youngsters during the first and subsequent visits to the dental office.

Without understanding and empathy, tolerance as well as patience soon fly out the window, and this first meeting becomes a confrontation. Failure at the beginning usually sets the pattern for further deterioration and the situation may be forever lost.

Dental literature is replete with papers dealing with the management of the already frightened and difficult child—how to control and re-educate such a patient (some psychologists call this "behavior modification"). No one will deny that there are many frightened and hard to manage children visiting dentists every day. Helping a youngster to accept dental treatment is an important part of any discussion involving negative child behavior, but because this paper is written for *The Journal of Preventive Dentistry*, the thrust of my position shall be to deal primarily with the prevention of childhood management problems in the dental office.

I feel that much of today's dental literature dealing with childhood behavior and emotional development has become pretentious and overladen with psychological jargon. "Modeling," "modalities," "operant conditioning," "target behavior" and "aversion therapy" might be considered a few such esoterica.

I do not intend to deny the validity of what these authors and investigators report, nor do I deny their legitimate quest for objectivity and preciseness, but often they get so tangled up in their own obtuseness that the conscientious student-reader becomes confused, turned off

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and perhaps, even left with the feeling that unless one knows this special language, one can't hope to deal successfully with children.

Let me reassure anyone who wishes to deal with and care for children . . . there is no special magic, no rare gift, no unique personality necessary. All that it takes are a few basis skills and knowledge, liberal doses of the aforementioned common sense, empathy, compassion, a sense of humor, honesty (with everyone involved—child, parent, self) and a sincere desire to serve the child.

This does not mean that anyone who cares for children must always be a paragon of patience, virtue and love. The practitioner is entitled to his or her own feelings, but the better he or she can control them when things do not go well, the easier it will become to deal with children. There will even be times when one must consciously attempt to behave in a different manner from the angry or hostile emotion felt at the moment, but the better one is able to do this, the sooner the time will come when difficult conscious efforts will slide into smooth unconscious patterns.

In short, anyone who expects to deal with children ought to know why children behave the way they do. They ought to feel reasonably comfortable in accepting childhood behavior that may temporarily thwart what they are trying to accomplish, and they ought to be able to accept, within reason, overt unfavorable behavior without losing their control of the situation and without losing there temper. Self control on the part of the adult is crucial; it always helps to slow down or stop runaway child behavior.

Lastly, a cardinal rule in helping to prevent childhood management problems rests squarely and solely with the dentist. Every practitioner who does not feel comfortable with children should honestly recognize this fact, explain his feelings to the parents, and then refer the child to someone who does enjoy working with and for children. Non-recognition or non-acceptance of these feelings on the part of the dentist invariably causes untold problems. An honest referral, on the other hand, immediately enhances the image of the referring dentist, for the parents realize it is the child's well being that is paramount to the dentist, not some personal ego or a fee. Of course, the patient's welfare is the very essence of professionalism.

With this brief introduction, let us explore the parts played by the three parties—the child, parents (usually mothers) and the dentist—involved with the prevention of behavior problems in the dental situation. The specific roles of the three participants cannot, nor should they be, considered as separate. In the beginning, relationships are constantly intermingling and changing. Later, after the dentist and child have established mutual ground rules and behavior limits so that they are comfortable with each other, the role of the parent should, and usually does, become minimal. Successful (preventive) patient management will be difficult unless all three parties involved have a mutual understanding of what is to be accomplished and then make a sincere effort to work together in an open spirit of cooperation.

In the past, both parents and dentists thought and acted as though it should be the child's responsibility to "behave" in the dental chair. Only recently, with the growing recognition that children have rights too, has the literature concerning child behavior in the dental environment, the objective and subjective contributions of those working with children, and finally the acceptance of dentistry for children as a recognized specialty, shown a changing recognition that the roles of parents and dentist are equally important. As a matter of prognostication, I would further suggest that there will be a growing recognition that the foundations of preventive childhood behavior problems are largely set by the personality and emotional makeup of the dentist.

Lastly, to those who wish to care for children, it is necessary to remember that there is never only one way to approach them psychologically. As adults we all differ widely, but by adulthood our basic patterns are pretty well established. Children's personalities at the age of three are still unsettled and unformed, although we may pick up clues if we are perceptive. Since children change so rapidly, there may not be one technique that will successfully handle all situations. Your own personality, feelings and sense of comfort may lead to changes or modifications in pattern, gestures and procedures. Flexibility when caring for children is essential.

What this paper will now offer are basic principles of child development and behavior, prag-

matic suggestions and workable solutions to the usual problems of first meetings. The principles are based on various schools of child psychiatric studies; the suggestions and techniques have been culled from the experiences and writings of numerous dentists who over the years are known to be happy working with youngsters and whose young patients are known to be content and comfortable with these dentists. To begin with, no one should attempt to care for children unless they have some understanding of how character, personality and physical growth and development take place. The average child by the age of three, although possessing many complicated skills, is still largely unformed, nearly totally vulnerable to the whims of adults, and extremely labile socially, physically, mentally and emotionally.

One basic idea to always keep in mind as well as in heart is that proposed and so beautifully taught by the late Dr. Ginott: "Put yourself in the child's place. Try to think how you might feel and respond with the meager emotional and mental equipment of a tiny child if you were suddenly thrust into a new and potentially threatening situation." If you can consistently do this, you will be the unique possessor of empathy, one of the priceless ingredients of good child-dentist relationships. When empathy is cultivated and nurtured it leads to patience and compassion, two other priceless ingredients of all human relationships, whether with child or adult.

It might be helpful to think of youngsters not as individuals merely smaller in size than adults, or as individuals already in a state of "being," but as persons in the act of "becoming." Children (under the age of 4) have had so few of life's experiences that they are unable to compare different things or people, are not yet capable of "weighing consequences" and do not yet know what is or is not dangerous to their bodies and psychies. In other words, they do not comprehend the realities of many new situations. They do, however, already possess one facet of their development that as adults we can make work for us —children, usually very early, develop self-concepts: "Am I loved?" "Am I capable?" Children with poor or negative self-concepts can be helped by a gentle, warm and accepting dentist to establish positive self-concepts. Perhaps that is what dentistry for children is all about.

Nearly everything the young child experiences is new and unfamiliar. Children under the age of four have not yet had the time or opportunity to assimilate and cope with all the thousands of sights, smells, sounds and new faces that literally assail them at every turn. Many incidents and spoken words that intrude upon their labile and developing senses give rise to feelings that may emotionally threaten to engulf the youngster.

This does not mean that the child must be treated like some delicate hothouse plant that will wilt or perish if left in the cold or wind, because as everyone should know, children are actually hardy, pliable and amazingly resilient. It does mean, however, that we should try to use the hardiness and resiliency of the child in positive ways . . . to help the child become cooperative and enthusiastic, and this can be readily accomplished by nurturing each child slowly and carefully.

As adults we have learned to take many things for granted. The very young child does not yet dare to take many things for granted, especially new places, new machinery and new faces. The more comforting, the safer and more honest the young child's previous life experiences and physical contacts with others have been, the more likely he will be able to accept and feel comfortable in a new environment with the dentist and the dental office. Fortunately for the dentist, most of the children we see for the first time *have* had such loving care and parental love. That is why (still to the surprise of many dentists and many more parents) the child will walk into a strange dental office willingly and trustingly, when gently and properly invited to do so. Now that this little child is willing to accept us on our word, it is absolutely imperative that we never betray or deceive such total and pristine confidence.

So far we have discussed the development and emotional state of the child; now it is time to introduce the importance of the dentist's feelings. Although most children will indeed tend to act cooperatively when given the chance, there are far too many dentists who still anticipate some unfavorable behavior reactions from the youngster. With such anxiety simmering near the surface, the tense

dentist lacking confidence may precipitate problems when none had existed previously. If the dentist's voice is gruff, if a friendly smile is lacking, if impatience is evident, a management problem may erupt. When the average healthy young child is about to cross the threshold of the dental operatory for the first time, he might be considered to be nicely balanced on the edge of an emotional precipice. Whether the child is "saved" or "pushed" is largely up to the adult.

Up to now I have tried to describe the basic feelings of the majority of healthy children who visit the office for the first time, but sad to say, there are still some children whose early life experiences (long before we have even had the chance to meet them in a dental environment) have been either physically or emotionally hurtful. These are the children who have not been able to build up self-concepts of worthiness or concepts of honesty or predictability. Obviously this has happened because parents (or other adults) have not behaved with honesty or predictability. It is quite logical for such a child to feel insecure and react with hostility, suspicion or even panic when confronted with a strange adult telling him something that may not turn out to be true. Children once "burned" by adults are sharp enough not to invite being "burned" again. Therefore, as dentists who hope to care for children, it is well to keep in mind that some of the children we shall see have been lied to, or have been mistreated and just because we know that everyone in the office is going to be nice doesn't mean the child will automatically and instinctively know it too. So if the child at first sight of you, the dentist, begins to cry, whine, hang back or even tries to run away, make an effort to recognize the basic nature of the youngster's resistance.

Does this fearful overt negative behavior have its genesis in poor parental relationships? Is the unproductive behavior merely a normal reaction to the newness and unfamiliarity of the situation? Is the child testing you or trying to manipulate you? Children, you know, are great natural manipulators, and if they can "get to you" they quickly know it and will exploit their advantage.

In any case, when negative reactions occur, the differentiation of the cause or causes may be difficult or impossible to make. One clue might be the severity and intensity of the reaction; the more severe it is, the more likely poor parental relationships are at fault.

No matter what the reason, it is at precisely this time that the dentist must deny a natural inclination to be upset or impatient. Impatience or disapproval, no matter how well we think we have hidden it, is uniquely evident to even the young child, and the tempo of anxious feelings can be quickly heightened to a frightening crescendo. It is strangely mysterious that children may not understand the reality of a new situation but they are so sensitively attuned to the nuances of negative facies, voices and attitudes of adults.

One of every child's basic needs is for acceptance of self as a loved and able person. This does not mean that the child's unfavorable or anti-social actions must be uncritically accepted or condoned (for this may become psychologically harmful and destructive if perpetuated), but it does mean that at the beginning of a dental confrontation, most of the giving and accepting should be done by the adult. I hasten to add that this is more easily said than done, but if in the beginning you give the young child some leeway to express or ventilate his anxiety, you will often be pleasantly surprised by the marvelous dental relationships that ensue.

The demeanor of the dentist and his staff should set the tone for this first meeting. It should be one of confidence, cheerfulness and non-scolding control. These first few moments, even when not all is sweetness and light, must not be parlayed into an adversary situation as so many well-meaning dentists seem to make it.

Of course, there are going to be occasions when some firm and positive control may be necessary and even welcomed by the child, but I don't think the first few moments of an introduction is that time. The more experienced and confident practitioner who feels reasonably sure of his ability to teach the child to eventually accept dental treatment gracefully and cooperatively need not get up tight about what so often is only transitory or momentary negative behavior. The dentist who "loses his cool" during these first few moments and insists on rigid control may have already lost the game. It is no great achievement to physically sub-

due a small child. It is, however, a great accomplishment to gently guide a young child to easy acceptance of dentistry.

Since it is basically the dentist's reactions and behavior that hold the key to prevention of child behavior problems, I think it appropriate to investigate another common roadblock to establishing happy relationships. Too many practitioners would prefer that their young patients sit motionless in the chair, not interrupting with speech, and just opening their mouths wide for the necessary treatment. Such dentists may be overly concerned with the techniques of their treatment and not enough concerned with the essential understanding of how the youngster can be helped and taught emotionally and mentally to deal with a stressful situation. We should not want children to be passively compliant on the surface just for the sake of placing restorations. We should instead want the child to cooperate because we have helped him to achieve higher levels of self reliance and self control with mutual involvement. Mutual constructive involvement invariably leads to strength of character and self confidence.

If you wish to work with children, it is well to remind yourself that most children do not need harsh or repressive controls at any time, but they will thrive on gentleness, sensitivity, patience, warmth and empathy—again that word "empathy."

Obviously not every dentist, no matter how capable and understanding of children, can succeed with every young patient, but if he makes an honest effort to be accepting of the child's temporary shortcomings, and honestly involves himself with the child's feelings, then he will be successful most of the time. What the individual dentist says and does, how he says it and how he does it, will, in the final analysis, be the fundamental determinant of good or poor childhood behavior patterns.

Now let us return to the reception room and discover whether this first meeting with our new patient is going to be an immediate joy or an instant challenge. Since I never know until I begin, I always use the same basic approach at the start. For the sake of this analysis, let us assume a less favorable situation—a crying, clinging or whining child. Although I might like to know if I am dealing with a truly fearful child, or the product of an overindulgent, anxious, rejecting or an overly authoritarian parent, it is not my prime concern at this point. I would also like to know if this is a child who has no idea of predictability because of misguided or dishonest adults, and, of course, it would be helpful to know if this is basically a shy, timid, withdrawn child or one with an aggressive personality.

Yet I feel quite frankly that the answers to these questions at this time are really academic and it matters little what kind of child I am dealing with during these first few moments. It should be enough to quickly recognize that here is a youngster with a problem and I am resolved to help with the problem. Until I learn differently (as I may at some later time) I automatically assume that this child is behaving logically for him. I must recognize that this is his unique way of coping.

At this point a slight digression is in order to introduce another basic concept of child behavior and development—the growth and use of language.

As adults, we have built up an extensive vocabulary of words to describe our feelings, to express our wants, needs, likes and dislikes, and most importantly, our fears. For the most part, we can pretty well verbalize our feelings, and furthermore, we have learned many of life's little tricks for getting along with others. Some of these "tricks" we have learned consciously and some unconsciously, but we are all well aware of the value and effects of flattery, praise, projection, self control and compromise and how they help us to get through each day. Without these and other human accommodations, we would all be living in a jungle of uncontrolled behavior and possible self-destruction.

Think now of the little child in your dental office for the first time. He has neither the life experiences nor the vocabulary to adequately express his thoughts and feelings in language. What the average child does have to ventilate fear and anxiety is a vocabulary of behavior and action.

When adults consistently act out their feelings in anti-social patterns, the indication is that they may be either neurotic or psychotic, but some degree of acting out of children in a potentially harmful or frighteningly new situation may be logical and appropriate, at least for the time being.

It is essential therefore, that we remember that much of a young child's behavior is actually his special language and we must train ourselves to listen carefully so that we may hear and understand the nuances of what the child may be trying to tell us.

This is why I always give every child the benefit of the doubt during our first meeting, and I think it is important to see him on his own terrain, the reception room, for our first conversations. The words one uses are important, but the tone of voice in which they are delivered may be even more significant. They should be authoritative without sounding harsh, calm without sounding disinterested and cheerful without being disingenous.

What the child needs right now is a simple clear cut explanation, in terms and words which he can understand, exactly what is going to happen. He is entitled to know who I am, what we are going to do together, how we are going to do it and finally, he ought to be specifically told what is not going to happen. Every young child in a new situation needs structuring; furthermore, just saying it once may not be enough. Retelling of the situation may be necessary for reassurance. The dentist can help the frightened child by telling him that he knows how the child must be feeling and explaining "even grownups feel funny when they come to new places and meet different people." Children respond magically to empathy.

My "patter" of introduction goes something like this. There is nothing startling or original about it. It is based on the principles of child development and larded with ample amounts of empathy, patience and understanding.

"Hi Susie. Oh say, I like your sweater; are those flowers on it roses or carnations? You know you look a little worried this morning in my office, but that's okay because everyone is a little scared about coming to new places and seeing new things. I would like us to become good friends, so I'm going to sit down near you and just tell you exactly what we are going to do today, because it's going to be easy, as you will soon see for yourself. One very important thing I must tell you first. I always keep my word to boys and girls and I will always tell you what we are going to do before we do it. There will never be any surprises in this office. So this morning we shall count your teeth to make sure they are all there, we will see if they are clean because if they aren't we will take a little toothbrush and brush them nice and clean, and maybe, just maybe, we shall take some pictures of your teeth. Now that's what we are going to do this morning. Come in and let us show you the rest of my office."

With that I simply take the child's hand and walk unconcernedly into the operatory. This approach and conversation works about 95% of the time, and that is a good average in any endeavor. If the child is still reluctant, but not overtly so, I say very surely, "You have my promise, I will not let any harm come to you. Now let's go in," and at this point, nearly every child will come in without further fuss.

Certainly there is often a looking back for Mother and that is quite normal. I am not a strong believer in keeping Mother out of the operatory during this first visit. My compromise is to reassure the apprehensive child that the door to the operatory will be left open so that Mother may watch, or I tell the child, "Mother may stand in the back of the room if you are quiet, if Mother is quiet and if you do not keep turning your head around to look for her—remember though, I said I always keep my promises, and if you cry or keep turning your head, then Mother will leave this room and stay out until we look at your teeth."

Years of experience have taught me that rules for keeping parents out or letting them in must be flexible. Sometimes my judgment turns out to be wrong, but I would prefer to err on the side of the child until events prove that I "have been had". It doesn't take long for me to recognize my errors in judgment, and then my conversation might go something like this:

"Mrs. Smith, I would like you to leave the room now since I want Susan to learn that I do keep my word. You know this is a learning situation, and this is something Susie and I must be able to work out for ourselves. I think we can learn to work together; Susan will be more self-reliant in similar situations; I assure you she will not be mistreated in any way."

To the child I then say:

"I want you to know one thing. This is my office and I make the rules here. I will treat you as nicely and quickly as you will let me, but no one gets out of this chair until I see their teeth and do whatever else must be done. The quieter you sit and the more you help me, the sooner we will get through—the longer you cry, the longer you will sit here. It's up to you how soon you get through."

When working with children, it is imperative that specific limits be set. The limits are always implied and some children can sense or even guess what they are. For most children however, specific limits must be

spelled out in detail in a calm, supportive and empathetic manner. Once the limits are set, we can introduce the next to last principle of childhood development, which must be understood if we are to be consistently successful in preventing behavior problems.

This is the basic principle of control. Nearly everyone accepts the fact that children have fundamental needs: to be loved, accepted, to feel secure, etc. There is, however, one other need which we sometimes tend to forget; children have a need to be controlled. Rather than a harsh, strident or punishing control based on fear, they need the kind of adult control that says, "I will make sure no harm comes to you; I will help you to be safe; I will help you to meet this new situation."

The child who comes into your operatory for the first time in hysterics or having a temper tantrum (which in many cases might be the same thing) feels extremely uncomfortable psychologically for this wild behavior. He actually doesn't want to accept the responsibility for such overt action, but doesn't know what to do or how to do it. When an adult comes along and says, in essence, "OK, that's it, no more," the child feels great relief that someone has taken the burden of action off his shoulders. Usually, then, it takes but a few moments for quiet to reign again. You, the adult, have taken the responsibility from the child and made it yours. When you bring, calm, supportive and firm, patient control to the child, it provides a seemingly magical, steadying influence and the child will appreciate how you have helped.

Finally, the last basic principle in helping a child learn to cooperate in the dental office is this—young children need generous helpings of support, encouragement and reassurance that they are being helpful as well as capable and that we do indeed like them.

Children have an uncanny way of living up to adult expectations. If the expectations are positive, the behavior will usually be positive. When we honestly praise youngsters for their efforts to help us, they will try even harder to please us.

Children will recognize and resent gushing, but they will appreciate and understand an adult who gives them credit for trying, does not always demand perfection and who tries to develop the child's own sense of ability. In evaluating the child's place in the dental situation, it may be even more important to aid the child in adding to his sense of worth than to place perfect restorations. After all, it is difficult or even impossible to perform fine technical dentistry unless the young child feels safe, secure and relaxed in the dental chair.

SUMMARY

If the small child is seen early by a competent and properly oriented (psychologically) practitioner, there is little likelihood that behavior problems will arise.

Dentistry is a learning situation. The dentist and staff are responsible for teaching the child to accept treatment with positive mental attitudes.

Understanding all aspects of child growth and development is absolutely essential in the prevention of behavior problems. An acceptance of these "peculiarities of childhood" is imperative.

The dentist may have to curb his impatience and drive to "get the dental work done" and concentrate on helping the child meet the situation.

Children are insecure in new situations. They need simple, clear cut explanations (in terms they can understand) about what will happen and what is expected of them.

Children's language is often a language of behavior—familiarize yourself with their unique methods of expressing themselves.

Set limits and be in control. The limits must be realistic for the young child . . . the controls must be calm, reasonable and patient.

Be unstinting in praise, support, reassurance and encouragement.

Try at all costs to put yourself in the child's place. Empathy is a priceless ingredient.

Tender loving care honestly felt and generously given will usually solve many behavior problems, and certainly prevent the greatest majority from ever occurring.

Emanuel Cheraskin M.D., D.M.D. to Receive A.S.P.D.'s Achievement Award

The American Society for Preventive Dentistry announced that Dr. Emanuel Cheraskin will be presented with the Annual International Award in Preventive Dentistry Research this year for his efforts in fostering clinical research and advancing the scientific discipline of Preventive Dentistry. Dr. Cheraskin will be presented with this award at ASPD's 7th Annual Scientific Conference in Denver, Colorado on Tuesday, June 21, at the Annual Awards Luncheon. Past recipients of this annual award include Dr. Harold Loe, Dr. Perry A. Ratcliff, Dr. Paul H. Keyes, Dr. Miles Markley and Dr. Basil Bibby.

Dr. Cheraskin's contributions to prevention have been as a teacher, scientist, author and in the field of international relations.

Dr. Cheraskin is an active staff member of the University Hospital and Hillman Clinic, University of Alabama Medical Center; Assistant Professor, Department of Medicine, University of Alabama Medical Center; and Professor and Chairman, Department of Oral Medicine, University of Alabama School of Dentistry.

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A.S.P.D. in the Rockies

The American Society for Preventive Dentistry will hold its 7th Annual Scientific Conference in two parts: Part I will be held in Denver, Colorado, June 18-21, 1977 and Part II in Steamboat Springs, Colorado, June 22-25, 1977.

Part I will feature a wide range of speakers and topics beginning Saturday morning with a keynote address entitled, "An Idea Whose Time Has Come" by Ken Olson and carry on the balance of Saturday, Sunday, Monday and Tuesday with the following speakers and topics: Robert Frazer—"Tommorrow's Humanistic Dental Practice"; Bev & Jerry Mittelman—"Prevention in the Third Party World"; Larry Lytle—"An Enthusiastic Approach to Dentistry"; Charles Sorenson—"Recruiting, Selecting, Hiring and Developing Humanistic Staff"; Jack Anderson—"Current Fluoride Concepts"; Karen Harris—"Sharing, Caring, Preparing Through Teamwork"; Emanuel Cheraskin—"Life Style & Oral Health"; John Diamond—"Applied Kinesiology"; Ken Olson—"Living With Stress Successfully"; Bob Barkley—"1977"; Mary Lou & Don Vollmer—"Getting People Started with Prevention".

Part II will feature 6 limited attendance workshops covering four half day sessions on Wednesday through Saturday. Workshop speakers and topics are as follows: John Diamond—"Applied Kinesiology"; Herman Corn—"Problem Solving Periodontics for the Family Dentist"; Rita & Stu Johnson—"Self-Helf Instructional Units"; Mary Lou & Don Vollmer—"Getting People Started with Prevention"; Bob Barkley, DuWayne Furman, Bud Ham—"The Helping Relationship"; Ken Olson—"Personal Awareness, Growth and Goal Setting".

Registration information may be obtained by writing A.S.P.D., Attention: Robert G. Bostrom, Executive Director, 435 North Michigan Avenue, Chicago, Illinois 60611.

Abstracts of Articles in This Issue of the Journal of Preventive Dentistry
(Remove page, cut along lines, file as 3″ × 5″ cards)

Korf, SR: The Prevention of Child Behavior Problems in the Dental Office. A Humanistic Approach. J Prev Dent **4** (March-April) 1977.

Abstract: Dentistry is a learning situation. The dentist and staff are responsible for teaching the child to accept treatment with positive mental attitudes. Understanding all aspects of child growth and development is absolutely essential in the prevention of behavior problems. An acceptance of these "peculiarities of childhood" is imperative.

Imfeld, Th, Muhlemann, HR: Evaluation of Sugar Substitutes in Preventive Cariology. J Prev Dent **4** (March-April) 1977.

Abstract: The regulations of the Swiss Federal Health Office for labeling of marketed confectionery as "Safe for Teeth" are explained. pH-telemetry allows the assessment, under almost natural conditions, of 1) acid formation in interdental plaque exposed to carbohydrates and 2) neutralization of plaque acids by salivary buffer. Examples of telemetric pH-recordings of plaque exposed to xylitol, sorbitol, POLYSORB® and sorbose are presented. Using two-channel pH-telemetry it is possible to differentiate between 1) acid formed by glycolysis in plaque, 2) acid formed by the entire oral microflora, and 3) dietary acids. Confectionery advertized as "Safe for Teeth" in Switzerland may not, during consumption and for a

Luscher, B, Lutz, F, McDermott, T, Muhlemann, HR: The Prevention of Microleakage and Achievement of Optimal Marginal Adaptation. J Prev Dent **4** (March-April) 1977.

Abstract: Conventional operative dentistry as today practised is inherently not conservative in nature. The principles of G.V. Black have normally required the sacrifice of considerable healthy tooth substance during restorative procedures. The margins of restorations placed into these conventional cavity designs have shown to be of unsatisfactory quality exhibiting fissures and gaps. An attempt, therefore, in an *in vitro* study has been made to develop a MOD restoration necessitating only minimal tooth substance removal and at the same time provide an excellent marginal adaptation and seal. By modification of the cavity preparation, utilization of

subsequent 30 minute period, lower the interdental, telemetrically recorded plaque pH below 5.7. Not only the fermentability of the sugar substitutes but also the degree of saliva stimulation by mechanical and chemical properties are relevant to the damage potential of confectionery.

acid-etching, application of a sealer prior to composite insertion and compression of the composite material during setting, these goals were realized. An experimental *in vivo* study and a long term control of 450 adhesive restorations have confirmed the *in vitro* results.

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Composition: Each teaspoonful (5 ml.) contains 1.0 milligram fluoride ion (from 2.2 mg. sodium fluoride) in an M/10 phosphate solution at pH 4 in lime, orange or cherry flavor. **Contraindications:** Do not swallow in areas where the drinking water contains more than 0.7 ppm F. **Precaution:** Recommended systemic dosage should not be exceeded, as prolonged overdosage may result in dental fluorosis. **Dosage and Administration:** Children age 3 and over—preferably at bedtime after brushing teeth. In areas where drinking water is devoid of fluoride (0-0.3 ppm), one teaspoonful (5 ml.) to be rinsed around and between the teeth for one minute before swallowing. When drinking water contains 0.4 to 0.7 ppm F, reduce dose to one-half a teaspoonful. When drinking water contains more than 0.7 ppm F, one teaspoonful (5 ml.) to be rinsed around and between teeth for one minute, *then expectorate.* Do not eat, drink or rinse mouth for at least 15 minutes afterward. **How Supplied:** 250 ml. and 500 ml. plastic bottles. Choice of orange, cherry and lime flavors.

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[1]Aasenden, et al., Effects of Daily Rinsing and Ingestion of Fluoride Solutions Upon Dental Caries and Enamel Fluoride, *Arch. Oral Biol. 17:* 1705-1714, 1972. [2]Frankl, S.N., et al., The Topical Anticariogenic Effect of Daily Rinsing with an Acidulated Fluoride Phosphate Solution, *JADA 85:* 1972. [3]Finn, S.B., et al., The Clinical Cariostatic Effectiveness of Two Concentrations of Acidulated Phosphate-Fluoride Mouthwash, *JADA 90:* 1975.

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JPD-04

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References: 1. Data on file, Block Drug Company, Inc. 2. Abstract of the Symposium on Mechanisms of Pain and Sensitivity in the Teeth and Supporting Tissues, Fairleigh Dickinson University School of Dentistry, Nov. 12-13, 1973, p. 15. 3. Goldman, H. M. and Cohen, D. W.: An Introduction to Periodontia, Fourth Edition, The C. V. Mosby Company, St. Louis, 1969, p. 74.

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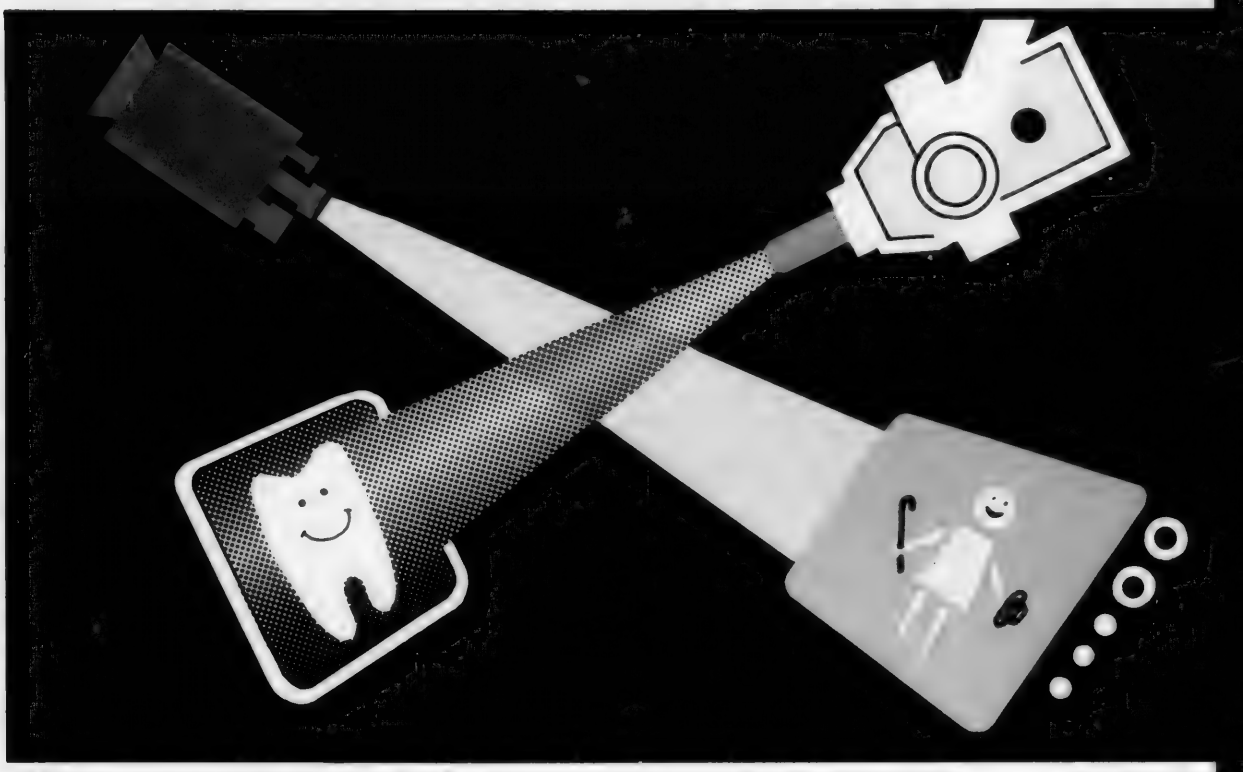

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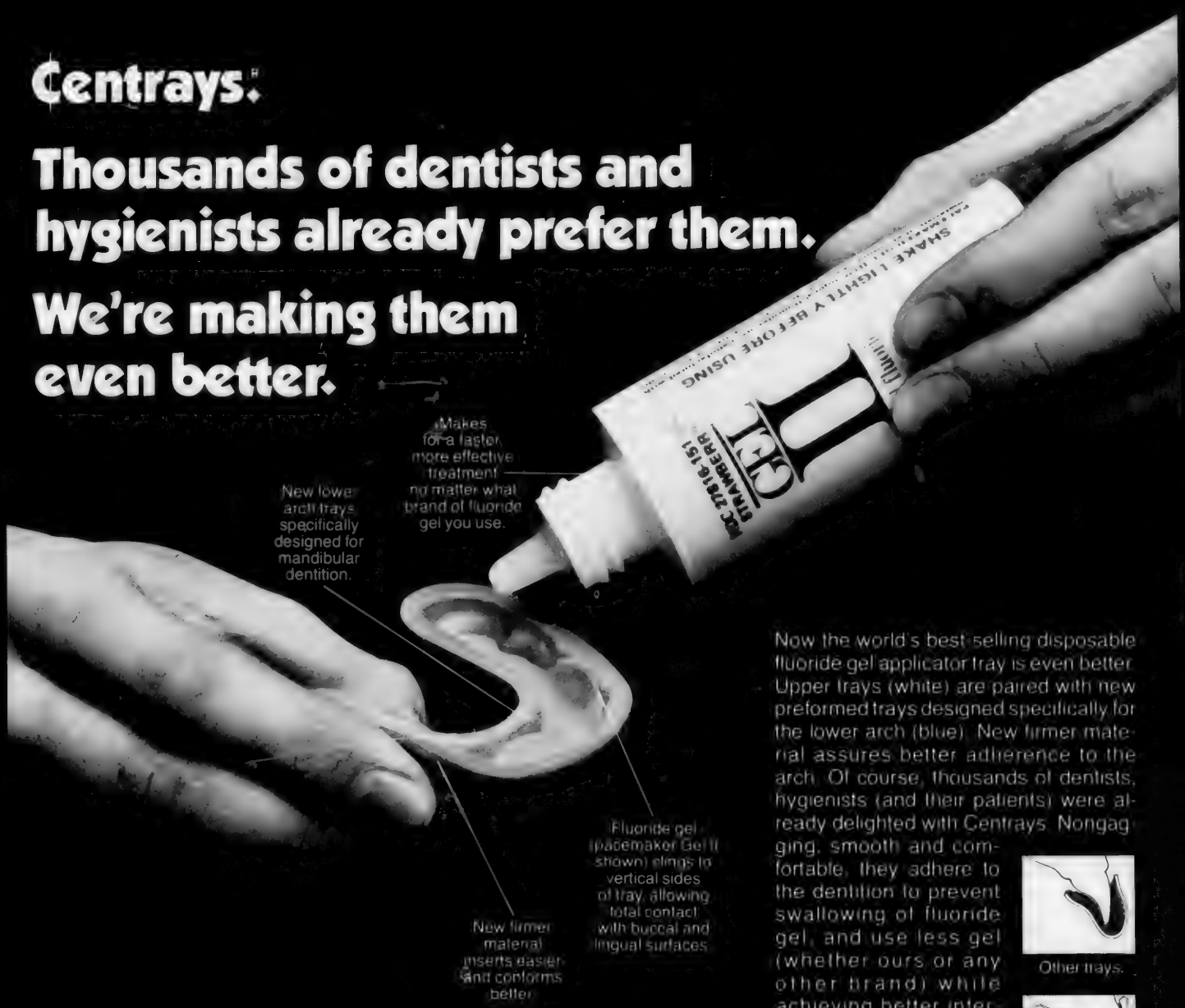
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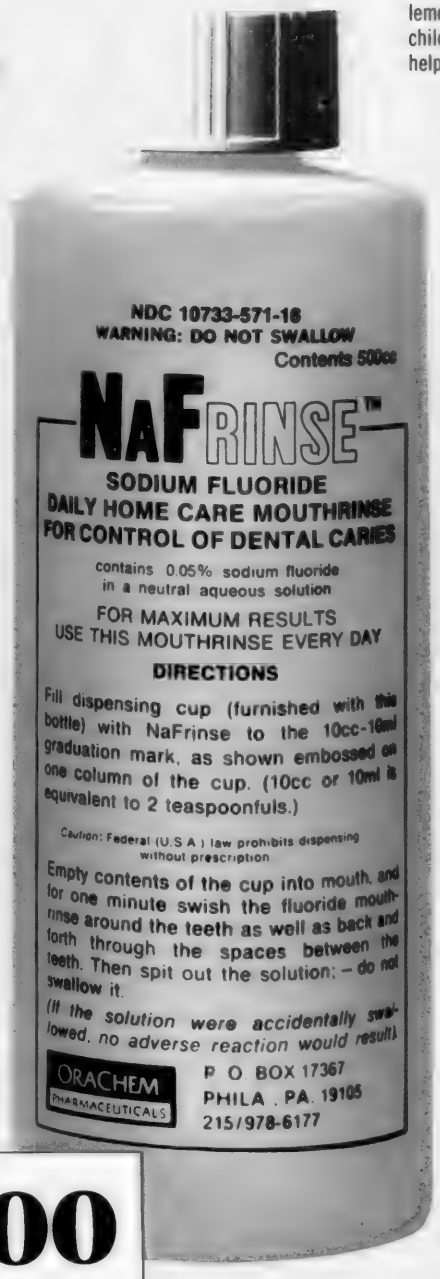
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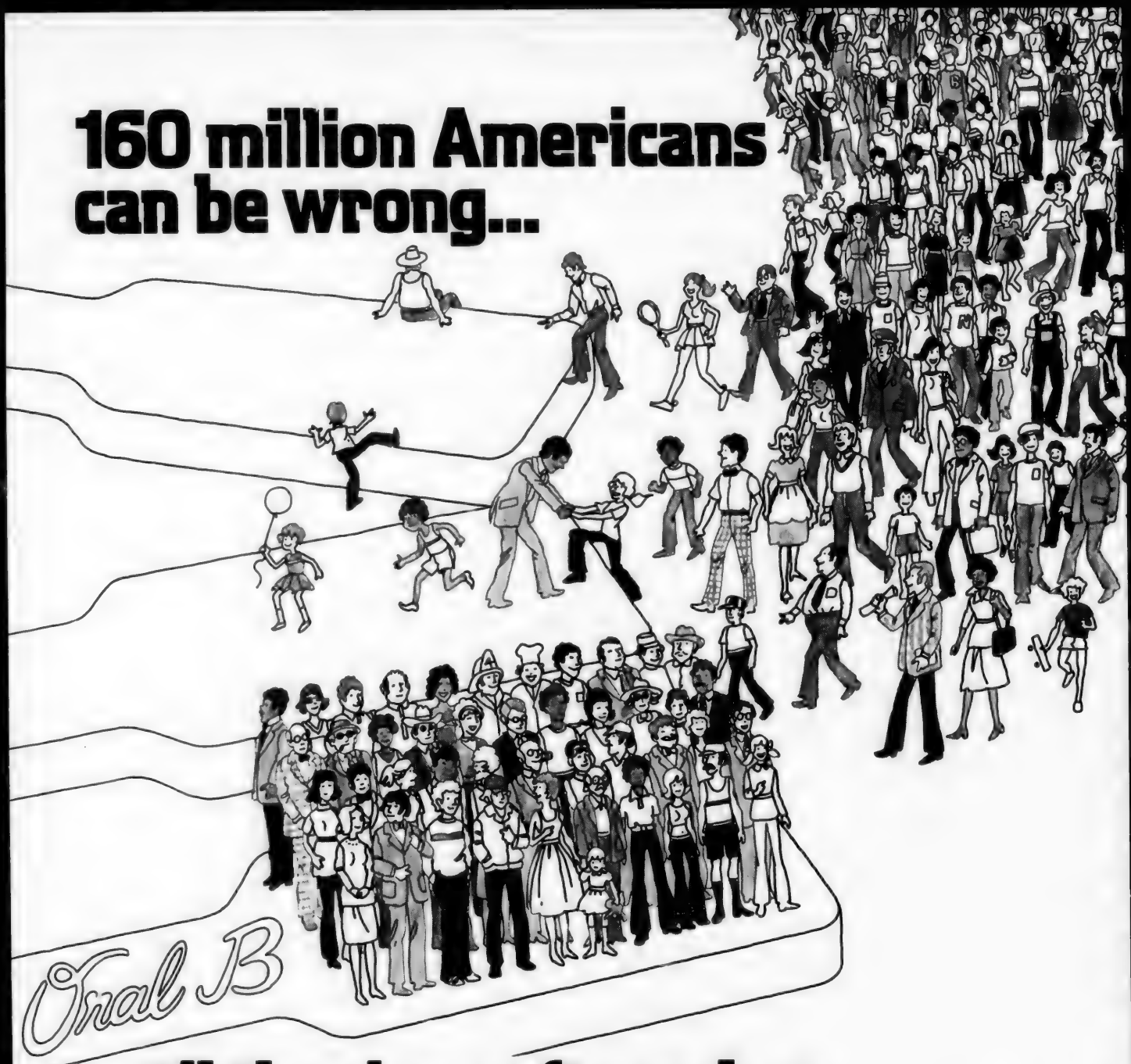

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THE JOURNAL OF
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contents

6 Preface to Symposium on Dental Radiology

Albert G. Richards

7 Rare Earth Imaging in Dental Radiology

Allan B. Reiskin, B.A., D.D.S., D.Phil., Erma Hummel, R.T., Susan Kirchhof, R.T. and Michael L. Freedman, A.B., Ph.D.

14 Dental Radiography with the Versatile Intraoral Positioner System

W. J. Updegrave, D.D.S.

21 Arch Length

Arnold J. Malerman, D.D.S.

28 Fluoride Supplements for Infants and Preschool Children

Stephen H. Y. Wei, D.D.S., M.S., M.D.S., James S. Wefel, Ph.D. and Frederick M. Parkins, D.D.S., M.S.D., Ph.D.

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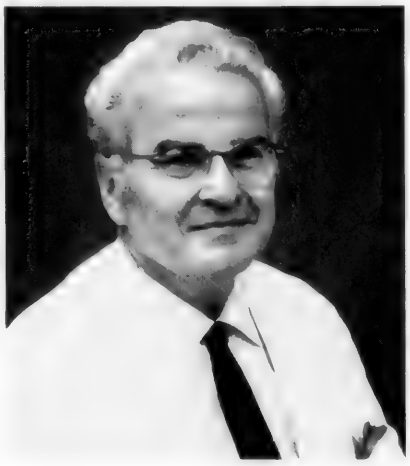
JPD-06

Preface

Albert G. Richards, B.S., M.S. Marcus L. Ward Prof. of Dentistry



The first dental radiograph was produced about 90 years ago, and the first x-ray machine made specifically for dental radiography was marketed about 50 years ago. During the last half century, the x-ray exposure of the dental patient has decreased about 98% mainly through the introduction of higher speed dental films.

In this issue Reiskin's article on "Rare earth imaging in dental radiology" describes a new family of fluorescent intensifying screens that permit further reductions in patient exposure resulting from extraoral examinations.

To record the maximum amount of diagnostic information for each exposure of the patient, requires that radiographs of only the highest quality are produced and the number of retakes be kept to a minimum.

Future issues will carry the following papers from this symposium. Crabtree's account of "Factors that influence quality of the dental radiograph" will list the causes of poor quality radiographs and their solutions.

Many radiographic faults occur during film processing procedures. The articles "Automatic film processing" by Thunthy and "Preventive care and maintenance of the automatic dental film processor" by Fortier will illustrate how film processing can be standardized to eliminate the occurrence of many of these faults.

Buchholz' article on the "Histologic-radiographic relation of proximal surface carious lesions" will confirm that the actual size and penetration of a carious lesion is minimized when seen in a radiograph.

Rare Earth Imaging in Dental Radiology

Allan B. Reiskin, B.A., D.D.S., D.Phil., Erma Hummel, R.T., Susan Kirchhof, R.T. and Michael L. Freedman, A.B., Ph.D.

Constraints imposed by the anatomy of the jaws and facial skeleton often determine the mechanisms of radiological procedures in dentistry. These constraints, until recently, have necessitated the use of small pliable films and small easily maneuvered x-ray tubes. Film has been the traditional recording medium for x-ray images in dentistry although other recorders are available. In a relative sense, direct exposure film is an inefficient recorder requiring large radiation exposures to produce adequate images. This inefficiency occurs because only a small portion of the x-ray energy is trapped in the emulsion of ordinary film. By contrast, energy from visible light is almost completely absorbed. The sensitivity of film to x-rays was first increased by applying thick emulsions to both sides of the film base. (Most photographic films have single emulsions.) The double emulsion approximately doubled the image density for a given exposure but caused some loss of detail. Additional increases in the efficiency of film recording systems were gained by converting x-ray energy into more readily absorbed light energy. This energy shift was accomplished by exposing film while in close contact with 'intensifying screens'.

Intensifying screens generally consist of a semi-rigid base upon which is placed a coating of a fluorescent salt incorporated into a suitable binder (Fig. 1A and B). The screens are held in close contact to the film by a spring-loaded metal cassette or other device. Obviously, the need for this additional bulk makes the intraoral use of film/screen combinations impractical. However, the growing use of extraoral films in many dental specialties and in particular the increasing use of panoramic and cephalometric examinations, has created interest in and need for the use of modern, fast, low dose imaging systems in dentistry.

From the Department of Oral Radiology, School of Dental Medicine, University of Connecticut.

Exposure of living tissue to x-rays involves a small but significant risk.[1] It is therefore desirable to use the fastest possible image recording system capable of providing essential diagnostic detail. Intensifying screens are the most commonly used devices for improving the efficiency of recording images on x-ray film. Traditionally, intensifying screens have been made with calcium tungstate, zinc sulphide and/or barium-lead-sulphate as the principle salts or phosphors. These materials were chosen because of their stability under constant x-irradiation, because they fluoresce immediately upon irradiation, and because the light which they emit lies in the blue and violet region of the spectrum where many film emulsions are sensitive. The speed or relative efficiency with which the intensifying screens convert x-ray energy to light is a function of many factors including the size and number of phosphor crystals, the type of phosphor, the ability of the phosphor to absorb x-ray energy and the spectrum of light emitted when the phosphor is irradiated.[2]

With any given phosphor, speed is usually a function of the size and number of phosphor particles. Increasing the number and size of particles increases the speed but often leads to a corresponding loss of image quality commonly seen as increased graininess, random noise, or mottle. In principle, it should be possible to increase the speed of intensifying screens without associated losses in image quality if phosphors with greater radiation-absorptive capacity could be substituted for those in current use. Theoretically, screen speed should also be increased by improving the efficiency of the conversion of x-ray to light energy and by broadening the spectral response of x-ray film.[3]

Economic pressures created by the growth of the color television industry created a demand for the development of a "new generation" of phosphors. Among those developed primarly for the use in color television tubes were a series of compounds made from the rare earth elements of the lanthanide series. The characteristics of these phosphors were close to those cited above for high-speed intensifying screens capable of producing high-quality radiographic images. The new phosphors, salts of lanthanum and gadolinium, proved to be more efficient absorbers of x-rays even at high energies where conventional calcium tungstate phosphors become relatively less effective.[4,5] In addition, the rare earth phosphors emit light over a broader spectral range than typical calcium and barium compounds. When the new phosphors are used with films having matched spectral sensitivities, they convert a broad range of x-ray energies into recordable, visible light. Thus, by increasing the usable range of x-ray energies and increasing the amount of x-ray energy converted into visible light, dramatic reductions in required x-ray exposure are obtained without serious loss of image quality, *i.e.*, the rare earth screen/film combination has a higher "speed."

The Photographic Products Division of the 3M Co. began marketing rare earth imaging systems under the trade name 'Trimax' approximately two years ago. Eastman Kodak has also been offering rare earth imaging systems under the trade name 'Lanex' for approximately one year. The x-ray films and intensifying screens which were first available were designed for use in general medical radiology and were manufactured in standard sizes. These products have been tested in specific dental applications such as cephalometry and conventional types of extraoral radiography. Systems in sizes and configurations suitable for use in panoramic devices were specially prepared by the manufacturers for the purpose of this study.*

This article will describe preliminary tests of these new products in panoramic and cephalometric applications.

* 3M Co., St. Paul, Minnesota; Eastman Kodak Co., Rochester, New York; General Electric Co., Milwaukee, Wisconsin.

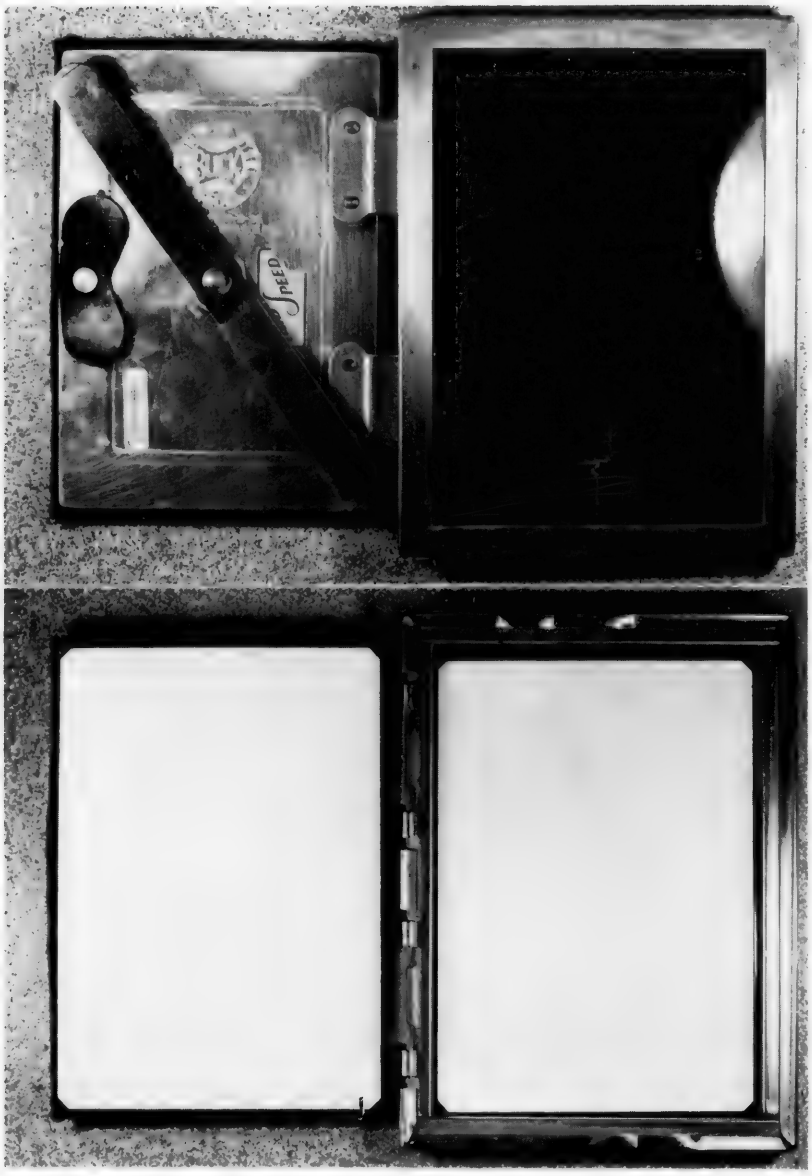


Fig. 1A and B (Top). The backside of an open cassette. The black surface is the side which faces the x-ray beam and the spring-loaded clamp is designed to maintain good film/screen contact. (Bottom) interior of the cassette with the exposed screen surfaces between which the film is sandwiched.

Measurements of the dose-reduction which can be attained with these systems will be presented and the technical advantage related to the design and use of x-ray generators and tubes will be discussed.

EVALUATION PROTOCOL

The availability of rare earth imaging systems raised three basic questions in dental radiology. First, was it possible to demonstrate that the quality of images produced with rare earth systems was equivalent to or better than the images produced by slower, conventional, intensifying screens. Although data was available on medical applications of rare earth recording systems there appeared to be no information on image quality in dental examinations.[4,5] Data on the quality of rare earth images in tomography was limited and no published reports on curved surface or panoramic tomography could be found. Second, could a meaningful reduction in patient radiation exposure levels be achieved through the use of rare earth imaging systems. Third, was it possible to demonstrate that the costs, exposure factors and processing requirements associated with rare earth systems were compatible with their use in the existing dental care delivery system.

IMAGE QUALITY

Image quality is the complex product of virtually every component of the x-ray system including the generator and tube, operating factors, geometry and technique, film/screen combination and processing. It includes the parameters contrast, density and resolution, etc. There are sophisticated techniques used to measure system performance including determinations of optical and noise properties expressed as point spread, line spread, or modulation transfer functions, etc. A less complicated approach was used in these preliminary studies. First, the resolving power of rare earth and conventional film/screen combinations was measured and compared. Several techniques were used including the exposure of resolution test targets such as those shown in Figures 2A and B. These targets allow quantitation of the ability to distinguish between discrete adjacent structures which are either converging or which are separated by decreasing intervals. Test-target exposures were carried out with the target, standing in air, placed in the focal trough of panoramic machines, or enclosed in a plastic scatter-producing container, or in a tissue-equivalent phantom of a human head (Fig. 2C). Exposures were also made with conventional and vacuum cassettes, the latter designed to improve the chances of obtaining good screen/film contact. Second, films of several tissue-equivalent phantoms were obtained using a variety of film/screen combinations. Exposure factors were adjusted to provide films of similar densities and specific anatomical structures known to lie within the pantomographic focal trough were compared. Finally, films were obtained on patients with a range of conventional and rare earth film/screen combinations and the films were submitted without identification to clinicians for their subjective evaluation.

DOSIMETRY

The change from conventional to rare earth imaging systems required

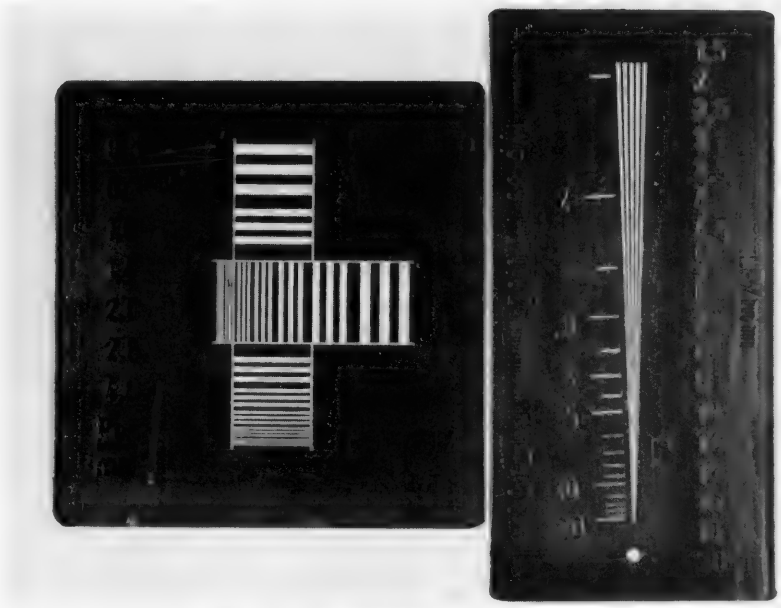


Fig. 2A. Two commonly used test targets.

significant reductions in mA.* Table 1 illustrates the average exposure factors required by several rare earth and conventional film/screen combinations. Slow or medium speed rare earth screens with compatible films required three- or four-fold reductions in mA to produce images of acceptable density.

Patient doses were measured by placing dosimeters at the exit slit of the tube collimator and in front of the film surface, where they remained during the entire exposure. Decreases in x-ray intensity due to the inverse square law were both calculated and measured directly and subtracted from the difference between the doses measured at the x-ray tube and at the film surface. Thus, by measuring the net amount of radiation reaching the film with and without a patient in the useful beam, a direct determination of the amount of radiation transmitted through or absorbed by the patient was obtained. A second measurement was made by placing dosimeters at the mastoid tip on the patient's right side for the duration of the exposure. The first measurement provided an estimate of the integrated dose experience of the patient and the second, done for comparative purposes[6,7] provided an estimate of the dose at a single anatomic site on the surface of the patient.

TECHNICAL AND ECONOMICAL CONSIDERATIONS

The broader spectral sensitivity of emulsions of films used with rare earth phosphors lead to questions about the compatibility of these films with some commonly used safe lights, processing chemistries, and tank vs. machine processing techniques. To resolve these questions, phantom and test target films were processed according to manufacturer's directions in tanks with Kodak dental developer for 4½ minutes at 68°, in a Kodak M6An X-Omat operating with a 90 second cycle at 95° with Kodak RP chemistry and in an S.S. White Auveloper using Kodak RP chemistry with 4½ minute processing cycle and a temperature of 78°. Films were subjected to visual inspection to access overall clarity and were subjected to densitometer measurements for the evaluation of the completeness of development.

(continued on page 11)

* A 'Panelipse' on which most measurements were performed was modified by the General Electric Co. to provide continuously variable selection from 0–15 mA.

Fig. 2B. The image produced when the target was radiographed in the focal trough of a G.E. Panelipse with one of the several film/screen combinations tested.

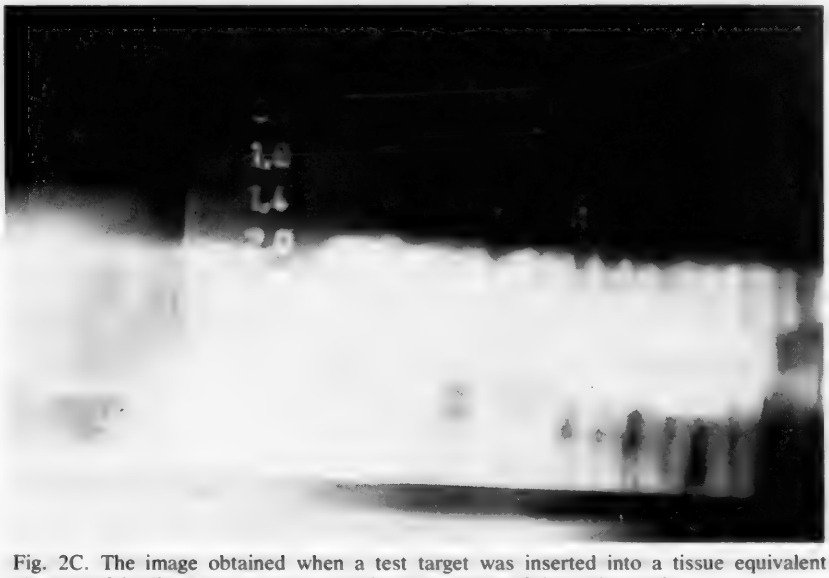


Fig. 2C. The image obtained when a test target was inserted into a tissue equivalent phantom: faint lines can be seen overlying the crowns of the molar teeth.

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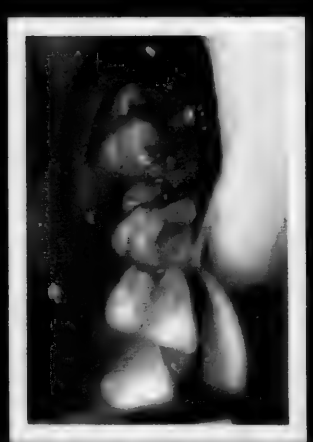

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(continued from page 9)

Unexposed films maintained in the x-ray facility were processed after different intervals of storage and after remaining unpackaged in the darkroom for intervals up to 5 minutes with illumination provided by a NuArk DBL-4* safe light.

RESULTS

Resolution

With few exceptions, test target measurements failed to show dramatic differences between conventional and rare earth imaging systems. The test series included the following combinations: Kodak X-Omatic intensifying screens with Kodak G, RP, Blue Brand and RP Royal films; Kodak Lanex screens with Kodak Ortho G film; 3M Alpha 4 and Alpha 8 intensifying screens with Trimax XD and XM films. An overall variation in resolution ranged from approximately ½ to 5 line pairs per millimeter when conventional cassettes were used (Figure 3). Variations in measured resolution were observed between sequential exposures with the same film/screen combination. The use of a vacuum cassette† tended to improve the consistency of repetitive exposures and resulted in higher resolution although not extending beyond the highest values measured with conventional cassettes. The exception was the combinations of Kodak X-Omatic screens with RP Royal film and 3M Alpha 8 screens with Trimax XM film which produced films of the lowest test target resolution. A limited number of measurements with conventional film/screen combinations from other manufacturers including U.S. Radium, Siemens, and DuPont did not differ significantly from the findings obtained with Kodak products. Results are summarized in Figure 3.

By visual assessment, rare earth systems appear to have slightly less contrast than their conventional counterparts while showing less evidence of recording scatter from the patient. Typical rare earth pantomographic images are illustrated in Figure 4.

Measurements with the highest resolution were obtained with a test target standing free in air. The lowest estimates of resolution were measured after the introduction of a small quantity of plastic as a scattering agent. Measurements made in a tissue equivalent phantom which was most nearly analogous to clinical reality fell just below the measurements made in air. The mean resolution observed in the phantom was approximately four line pairs per millimeter. Clinicians were unable to distinguish between properly exposed rare earth and conventional film/screen combinations.

Dose

Integral absorbed doses, measured as described with hot press lithium fluoride chip dosimeters and an Eberline Model TLR-5, averaged 2.995 R with a range of 2.610 to 3.317 R for G film with X-Omatic screens exposed to optimal densities with a G.E. Panelipse. The average exposure measured with radiographs of comparable density using Alpha 8 screens and Trimax XD film was 1.107 R with a range of 1.38 to 0.914 R. Patient physical size in the two groups were roughly comparable.

Surface measurements at the right mastoid tip averaged .130 mr with the X-Omatic/G combination and .065 mr with the Alpha 8/XD combination. A limited evaluation of Lanex screens with Ortho G film suggests a response similar to that obtained with Alpha 8 screens and XD film. The data is summarized in Table 2.

TECHNICAL EVALUATION

Standard darkroom tests demonstrated that rare earth imaging systems could be handled under conditions which were comparable with the processing of commonly used dental x-ray products. Limited testing provided no evidence of an increased risk of visibly detectable fog resulting from exposure to safe lights or from the range of temperature and humidity normally encountered in a clinical darkroom. Films processed by hand in tank chemistry or by machine yielded comparable results based on densitometric and subjective evaluation. No attempt was made to evaluate films for archival quality in any processing mode and no chemical analyses were performed on the processed emulsions or film bases.

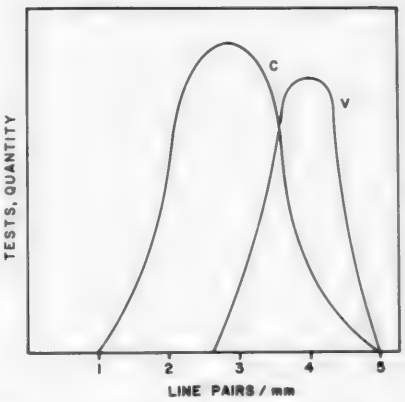

Fig. 3. Summary of resolution measurements using a variety of film/screen combinations with conventional cassettes (C) and vacuum casettes (V).

DISCUSSION

Although the data presented here represent a preliminary evaluation of new products which will require additional and more rigorous investigation, it is clear that rare earth imaging systems offer many advantages. First, our limited tests demonstrate that image quality measured by several techniques

Table 1. Approximate exposure factors for several film/screen combinations.

Screen	Film	mA	KVP
X-OMATIC REG.	X-OMATIC G	8	80–90
ALPHA-4	TRIMAX X-D	4	80–86
ALPHA-4	TRIMAX X-M	2	70–80
ALPHA-8	TRIMAX X-D	2	75–85
ALPHA-8	TRIMAX X-M	2	65–75
LANEX REG.	ORTHO-G	2	75–85
X-OMATIC REG.	RP ROYAL	2	70–80
X-OMATIC REG.	BLUE BRAND	4	70–85
X-OMATIC REG.	RP X-OMAT	4	75–85

"TRIMAX" and "ALPHA" are 3M Co. Products.
"X-OMATIC", "LANEX," and "ORTHO-G", "RP" and "BLUE BRAND" are Eastman Kodak Products.

* NuArk Co., Inc., 4100 West Grand Ave., Chicago, Illinois.

† Provided courtesy of E-Z-Em Co., New York, New York.

Fig. 4. This image was produced with 3M Co. Alpha 8 screens and XD film processed through a Kodak M6An X-Omat on a 90 second duty cycle.

is comparable to conventional film/screen systems. In many instances, there is evidence indicating that these recording systems produce superior images in that they record less scatter. In the introduction, it was noted that the effectiveness of rare earth phosphors is partly attributible to their greater capacity for absorbing as opposed to transmitting x-ray photons of high energy. It must also be pointed out that these phosphors are less sensitive to x-ray energies below 50 kV. Because the majority of x-ray photons which generate useful information on film are those of higher energies, and photons which contribute primarily to non-specific density or noise from scattered radiation are those of lower energies, the rare earth systems record a higher ratio of useful information to noise than their conventional analogs. This observation has been particularly dramatic in cephalometric radiography where it had been necessary to use grids or other devices to eliminate scatter when using regular screens. In our hands, grids or other scatter-reducing devices have been unnecessary with either the Trimax or Lanex systems. The use of a grid commonly requires increasing exposure factors.

The most significant advantage of rare earth imaging systems is the dramatic reduction in patient dose which results from their improved efficiency. The radiobiological literature contains data which shows that measurable damage can be demonstrated in living tissue at dose levels in the hundred millirad range.[8–10] Some studies suggest that doses in the range of 5 rads may alter the incidence of cancer occurring in sensitive target tissues or may increase the risk of tumor induction by other mechanisms.[11,12] In the two examples cited here, tomographic and cephalometric radiography, the examinations involve exposure of a large volume of tissue in individuals who are often young and in more susceptible age groups. Technological improvements which permit significant dose reductions without measurable loss of image content or quality are powerful tools with important biological implications.

The reduced requirement for x-ray output is advantageous for several other reasons. First, even with existing machines there is likely to be a measurable increase in the useful life of the x-ray tube and generator. Second, the reduced loading of the x-ray tube makes it possible to use x-ray tubes with smaller focal spots which have the potential for producing images with higher resolution. In addition, the size and cost of x-ray units could be reduced.

Unfortunately, many machines operate at a fixed mA or limited KVP and mA selection. In these instances, it is not practical to use rare earth imaging systems since they are most effective with high kilovoltages and low mA. The mA required often in the range of 1½ to 5, is below that attainable with most modern panoramic machines.

In cephalometric and other non-tomographic applications, this problem does not exist since one can operate with higher mA settings by reducing the exposure time. This maneuver offers yet another advantage in minimizing the possibility of patient movement.

Although the facility in which this study was carried out has been designed and is operated to meet institutional needs and is not totally comparable to the darkroom facilities in a dental office, we have demonstrated that with cautious handling, rare earth imaging systems can be used in dental offices and clinics without major modifications of their darkrooms or processing facilities. At the present time, the cost of rare earth intensifying screens is substantially higher than the cost of conventional screens and the cost of compatible film is approximately 10% more than the equivalent conventional film. While the additional capital expenditure and increased operating cost may seem large, it is probably offset

Table 2. Exposure Measurements with Rare Earth and Conventional Film/Screen Combinations*

			Transmission Measurements During Entire Exposure			Surface Measurements At Right Mastoid		
Co.	Film	Screen	Number	Mean	Range	Number	Mean	Range
3-M	X-D	A-8	15	1.107	1.386 ↓ 0.914	8	.065	.080 ↓ .031
Kodak	X-G	Reg	13	2.995	3.317 ↓ 2.610	7	.130	.137 ↓ .074

* Lithium fluoride chips were calibrated against a cesium source and the possibility of an error in the stated dose rate cannot be ruled out. The ratios of measurements for different film/screen combinations remain valid. Exposures measured in millirems are consistent with other data in the literature.

by increased tube and machine life and savings in related areas. In biological terms, the dose sparing potential seems clearly to be worth the additional investment.

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Dental Radiography with the Versatile Intraoral Positioner System

W. J. Updegrave, D.D.S.*

The detection of dental pathosis in its incipiency is as vital as its prevention and the role played by radiography in this aspect of the diagnosis cannot be overemphasized. Therefore, since an accurate diagnosis requires radiographs of excellent quality, every effort must be made to produce anatomically accurate images with minimal distortion.

If such radiographs are to be produced, it is a well-established fact that the Paralleling Right-Angle principle must be followed[1–7]. By positioning the film parallel to the long axes of the teeth being radiographed and then directing the x-ray beam perpendicular or at right angles to the film surface in both vertical and horizontal planes (Fig. 1), such radiographs will be produced. This relationship automatically eliminates horizontal and vertical angular distortion as well as dimensional distortion of the radiographic image, the latter being an unavoidable characteristic of radiographs taken with the bisecting-angle principle.[5]

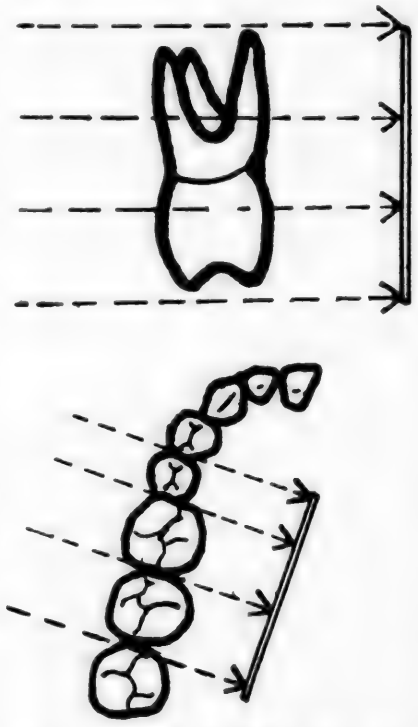
To accomplish this Paralleling Right-Angle technic in a standardized and simplified manner, newly developed instrumentation, the Versatile Intraoral Positioner System (V.I.P.) has been designed and is now commercially available.* It is a film-holding, beam-directing device which facilitates paralleling the film with the teeth and then presents a target for aligning the open-end *long or short tube* of the radiographic unit establishing a right angle projection of the x-ray beam to the film.

The Versatile Intraoral Positioner is constructed of light-weight material and consists of three basic parts (Fig. 2):

1. FILM HOLDERS fabricated in three sizes to accommodate narrow and standard size films positioned either vertically or horizontally.

2. COUPLER one end of which inserts into the film holder to retain the film in place and the other end with receptacles for the target.

3. TARGET which is inserted into the coupler and is designed with a flat, elliptical color-coded surface for alignment of the x-ray positioning tube. Metal backing plates to prevent curvature of the film and slip-on soft plastic bite pads for the film holders to establish stability of the film position and also increase patient comfort are accessories of the V.I.P. system.

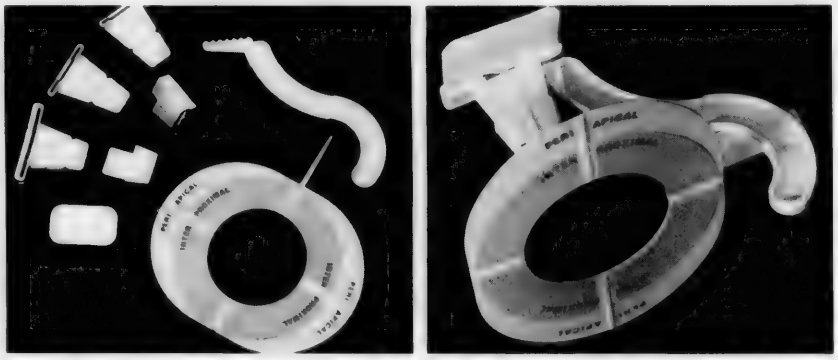


FIGS. 1A and B. The Paralleling, Right-Angle principle in dental radiography. (A, Top) Vertical angulation. (B, bottom) Horizontal angulation.

PERIAPICAL TECHNIC

For periapical radiography the desired film holder is selected, (#1-V for narrow films used vertically, or #2-V for standard size films used vertically or #2-H for standard films used horizontally). To radiograph the right side, the embossed "R" on the biting surface of the film holder is faced upward and the film is inserted into the slot above the biting surface for maxillary exposures or below the biting surface for mandibular exposures. The "L" is faced upward and a similar procedure followed for radiographing the left side. This simplifies instrument assembly for all areas. The metal backing plate is then inserted into the slot behind the film and the serrated end of the coupler inserted firmly into the channel on the side of the film holder to retain the film in the selected position.

With the color-coded surface of the target faced away from the film, the projecting arm is inserted into the receptacle at the opposite end of the



FIGS. 2A and B. (A, left) Components of the Versatile Intraoral Positioner system. (B, right) Assembled Versatile Intraoral Positioner for radiography of the maxillary right or mandibular left posterior teeth.

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FIG. 3. Tube-target alignment for anterior mandibular exposure (left) maxillary molar exposure (center) posterior bite-wing exposure (right).

coupler. The bite pad is then slipped onto the biting surface of the film holder with its thicker portion positioned for contact with the opposing teeth. The completely assembled instrument is now ready for positioning in the mouth (Fig. 2b).

There is a raised center line on each film holder indicating the center of the film. This simplifies positioning and guarantees that the desired area will be covered or the selected contact areas will be opened. The film is positioned well-lingually to establish a parallel relationship with the teeth (this also reduces any discomfort to the patient), the biting surface of the holder is maintained firmly on the occlusal surface of the teeth being radiographed and the patient instructed to close tightly on the biting pad of the instrument to retain it in the selected position.

The open end directing tube of the radiographic unit is then paralleled with the face of the target and aligned with the proper circle—the top for maxillary exposures, the lower for mandibular exposures and the center circle for interproximal (bite-wing) exposures (Fig. 3). The complete 20 film radiographic survey produced with this technic and including vertical interproximal (bite-wing) radiographs is seen in Figure 4. Black plastic clear-edge mounts for such a survey are commercially available from the same source as the V.I.P. instrument.

VERTICAL INTERPROXIMAL (BITE-WING) TECHNIC

Conventional *horizontal* interproximal radiographs can be taken with the Versatile Intraoral Positioner by inserting a standard #2 size film horizontally and midway in the #2-H holder, positioning it conventionally in the mouth and aligning the directing tube of the radiographic unit with the center circle of the target. The bite-wing films in Figure 5 (Top Row) were taken in this manner.

The objection to conventional bite-wing radiographs such as these however, is the limited crestal bone coverage resulting from the opened occlusal relationship caused by the biting portion of film-holding instruments. This led to the development of this vertical interproximal technic which is accomplished with the Versatile Intraoral Positioner by inserting standard size films *vertically* and midway in the film holders. The increased crestal bone coverage in these vertically taken bite-wing radiographs over the conventionally taken horizontal films is seen in Figure 5 (Bottom Row).

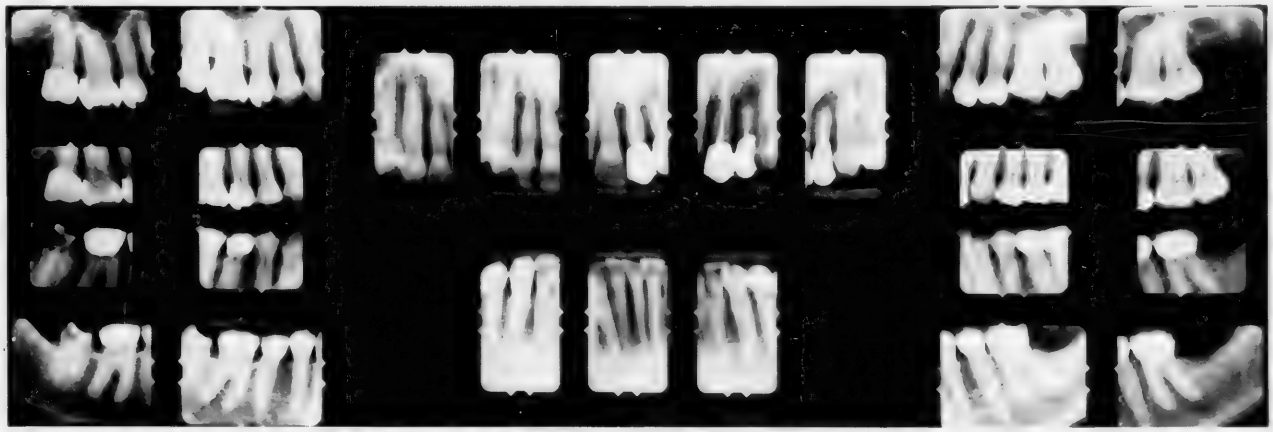

FIG. 4. Complete (20 film) periapical and vertical bite-wing survey.

FIG. 5. Top row; Conventional horizontal bite-wing radiographs. Bottom row; Vertical bite-wing radiographs.

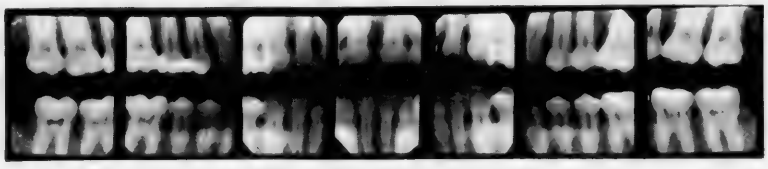

FIG. 6. Complete 7 film vertical interproximal (bite-wing) survey.

Anterior bite-wing radiographs can also be taken with the V.I.P. instrument by utilizing narrow #1 size films vertically and midway in the #1-V holders. The accuracy and advantage of anterior and posterior vertical bite-wing radiographs as a complete interproximal survey for interproximal caries as well as for periodontal disease recommends this procedure as a supplement or as an integral part of the routine periapical and panoramic examinations (Fig. 6). Black plastic clear-edge mounts for this examination are available from the same source as the V.I.P. instrument.

PEDODONTIC RADIOGRAPHY

Film positioning presents the greatest problem in pedodontic radiography since the regular size film required for adequate area coverage is often unacceptable to the child while the child size ("O") may be acceptable but fails to cover the desired area. The versatility of the V.I.P. instrument largely overcomes these problems by offering the operator various methods to utilize all sizes of film to cover the desired areas with minimum discomfort to the child. For example, the anterior occlusal technic for children of all ages using standard #2 size periapical films or the large occlusal films is readily accomplished with the occlusal film holder of the Versatile Intraoral Positioner (Figs. 7A and B).

Radiography of the posterior teeth of the pre-school age child can be accomplished by inserting an "O" size or #1 size film mid-way in the #1-V holder of the V.I.P. instrument and making a bite-wing type exposure (Fig. 7C). A fourfilm survey of this type including the anterior occlusal exposures is seen in Figure 7D.

For periapical coverage of the first permanent molars, the standard #2 size film is used *vertically* in the #2-V holder by inserting it to the position where the

(continued on page 18)

FIGS. 7A–C. (A, left) Maxillary anterior occlusal technic with the V.I.P. system. (B, center) Mandibular anterior occlusal technic with the V.I.P. system. (C, right) Posterior bite-wing technic for the young child.

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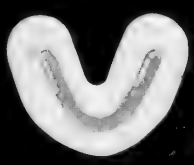

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FIG. 7D. Resultant radiographs of technic.

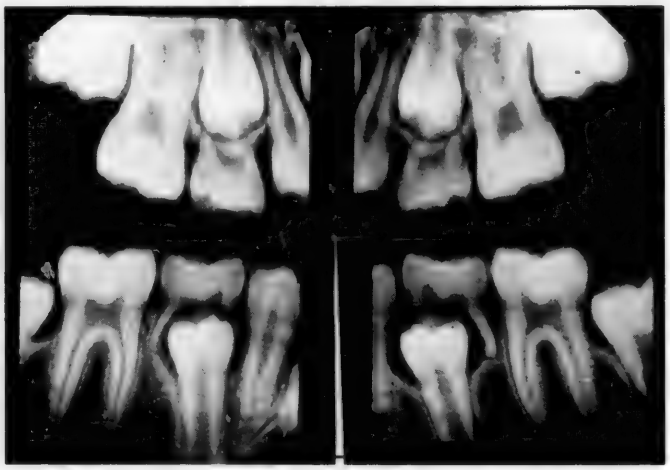

FIG. 8. Periapical radiographic survey with standard #2 size films adapted in the V.I.P. system.

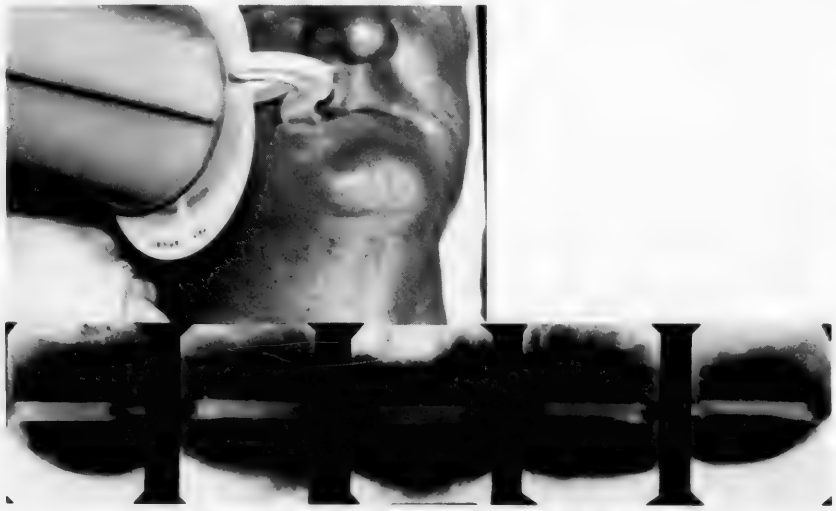

FIG. 9. Edentulous bite-wing technic with the V.I.P. system.

(continued from page 16)

film surface will cover the desired area, the film extending upward out of the holder slot for maxillary exposures and downward for mandibular exposures. This will provide a somewhat square shaped film area which gives ample periapical coverage and at the same time is acceptable to the patient because of the narrower mesial-distal width of the film and the more lingual positioning of the film made possible by the extended biting surface of the film holder (Fig. 8).

EDENTULOUS RADIOGRAPHY

Radiography of the edentulous jaws is essential to the diagnosis as radiography with the teeth present. Some investigators[8–13] support this statement in their radiographic findings in which 25 to 35% of clinically edentulous jaws revealed retained roots, embedded teeth, cysts, neoplasms and other entities significant to the diagnosis and therapy.

A five-film bite-wing radiographic survey of completely edentulous jaws can be made with standard #2 size films positioned mid-way and vertically in the 2-V holder of the V.I.P. instrument which is modified by attaching bite pads or large cotton rolls to both sides of the biting surface to compensate for the missing teeth (Fig. 9).

Individual areas can also be radiographed with the standard #2 size film in the 2-H and 2-V holders with the required amount of film surface protruding from the slot. A 10-film complete edentulous survey of this type is seen in Figure 10. Occlusal exposures of the anterior areas can also be made with the V.I.P. occlusal film holder.

SUMMARY

The routine production of anatomically accurate radiographs with minimum distortion facilitates their interpretation. The important role played by such radiographs in the prevention of diagnostic error cannot be overestimated. Standardized and simplified clinical procedures to produce such radiographs require film-positioning and beam-directing instruments the utilization of which should be readily understood and quickly mastered to make them of clinical value to the dentist and his auxillary personnel. The Versatile Intraoral Positioner System (V.I.P.) has been designed to accomplish these objectives. Periapical, Vertical Bite-Wing, Pedodontic and Edentulous technics which can be accomplished with the V.I.P. device are briefly described.

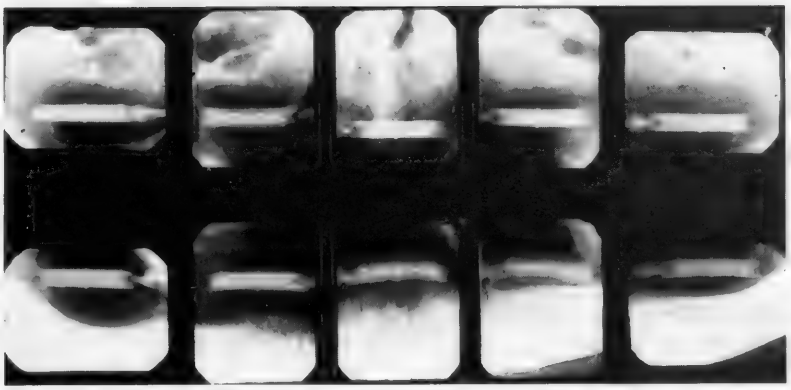

FIG. 10. Ten film edentulous survey using standard #2 size films in the V.I.P. system.

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Sumter S. Arnim, B.A., D.D.S. to Receive Citation of Merit from A.S.P.D.

The American Society for Preventive Dentistry announced the granting of a special award this year. Dr. Sumter Arnim will be presented with a Citation of Merit at ASPD's 7th Annual Scientific Conference in Denver, Colorado on Tuesday, June 21 at the Annual Awards Luncheon. This will be a continuing award which ASPD has established for honoring dental health personnel (doctors, students, auxiliaries) for their achievements.

Dr. Arnim has added a new dimension to the understanding of the ecology of the bacteria of dental microcosm, and the importance of daily control, particularly through his studies using phase contrast microscopes and cinemicrographs. His articles, movies and lectures have inspired the present interest in the control of bacterial plaque as evidenced by today's prevention minded dentists.

Dr. Arnim's most valuable contributions to Preventive Dentistry were made while he was Professor of Oral Pathology at the University of Texas, Dental Branch at Houston, 1947 through 1970. Dr. Arnim served as Dean of the Graduate School of Bio-Medical Sciences at the University of Texas from 1970 through 1974. He is presently retired and residing in Brownsville, Texas.

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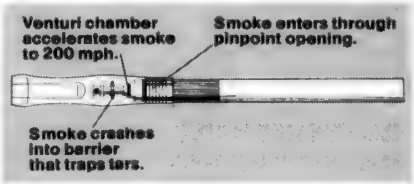
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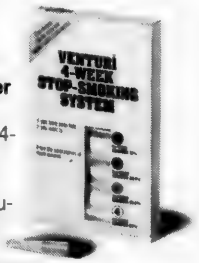
- Nicotine poisoning symptoms include dizziness, rapid pulse, cold and clammy skin, nausea and vomiting. Habitual smokers may sometimes experience these symptoms and attribute them to other causes.
- Aside from the hazards of nicotine addiction, smoking exposes your patients to carcinogens. Smokers are also more prone to cardiovascular and respiratory diseases.



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Arch Length

Arnold J. Malerman, D.D.S.*

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"I'm delighted to hear that, Dr. Molar," Mrs. Parent replied. "But tell me, why do Johnny's new front teeth seem so crooked? They're all jumbled up. His baby teeth were so nice and white and straight, and these new teeth seem so large. I'm really very concerned."

Dr. Molar looked again at Johnny's mouth and said, "They do seem large and crowded, but your son is only seven. His jaws still have a lot of growing to do. Perhaps they will grow enough to support his teeth."

"Perhaps," that vague and unscientific term. Johnny presented with an obvious problem, anterior crowding, which is indicative of an overall arch length deficiency. There is no "perhaps" about it. Johnny either has or does not have an arch length deficiency. There are means available to accurately make this determination.

TYPES OF ARCH LENGTH DISCREPANCY

Three types of arch length discrepancies exist.[11] The first and by far the most common is an excess of tooth material in relation to the amount of basal bone that exists to support the teeth, ultimately resulting in crowding of the dentition.

The patient who has been totally edentulous for twenty years has nothing left but basal bone. This basal bone, or apical base,[13] is genetically determined and remains unchanged whether teeth are present or not. The alveolar bone, the denture bearing ridge, exists to support teeth. Once the permanent teeth are lost, the alveolar bone is also lost. In the arch length deficiency, the basal bone or apical base is insufficient to carry all of the teeth and their concomitant alveolar bone.

The second problem is the exact reverse of the arch length deficiency. In this case, we are presented with an arch length excess. The amount of tooth material and its associated alveolar bone is small in comparison with the basal bone. The overall result is spacing between the teeth.

The third problem is one of a tooth-size to tooth-size discrepancy, the teeth in the maxillary arch not matching those in the mandibular arch, making normal occlusion unattainable.

GENETIC DRIFT

From our prehistoric forebearers to man as we know him today, the evolutionary trend has been one of reduction of facial dimensions.[24] Genetic drift has allowed for diminution in both the skeletal framework of the face and the dentition. But man's face is getting smaller at a greater rate than his teeth. The overall result is one of an increasing tendancy toward dental crowding.[18]

For stone age man, arch length discrepancy was rarely a problem.[6,7] Proximal attrition and occlusal attrition to below the level of the contact points[8] allowed eruption of the full adult dentition into uncrowded positions. With civilization and refinement of food products, modern man has lost attrition as a positive factor in the eruption of his dentition.[19]

Normal development of the dental arches toward the goal of a functional occlusion, being thus challenged by genetic trends, is often not achieved. The dentist, whose task it is to monitor this process, is faced with a complicated diagnostic and treatment situation. He must determine whether there will be sufficient room for all of the permanent teeth to erupt into normal occlusion. If not, he must then determine the best course of treatment for his patient, which may include referral to an orthodontist or pedodontist for growth and development supervision.

EXTENT OF THE PROBLEM

Salzmann[35] has pointed out that "Ideal occlusion is a hypothetical formula which does not, and cannot, exist in man. Ideal tooth form and ideal occlusion

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necessitates an unblemished heredity, an optimum favorable environment and a developmental history devoid of any accident, diseases or occurrence which would modify the ideal inherent growth pattern."

It has been determined[16] that 50 to 60 per cent of the children in the 10 to 19 year age group have some degrees of malocclusion. Of these, more than half[3] have a moderately severe to handicapping malocclusion.

The inter-relationship of abnormalities comprising a malocclusion, both dental and skeletal, are extremely complex. Arch the maxillary deciduous laterals and canines, and the mandibular deciduous canines and first molars. The flush terminal plane relationship of the second deciduous molars is altered to a full Class I relationship at eruption of the first permanent molars. This "early mesial shift"[5] occurs *via* closure of the primate space, allowing the first permanent molars to erupt into a full Class I relationship.

In the second most common dental pattern, primate spaces are absent.[4] Due to the flush terminal plane relationship, the first permanent molars are forced to erupt into an end-on, cusp-tip to cusp-tip relationship. "Late mesial shift"[5] occurs at eruption of the permanent canines and premolars, allowing the mandibular molar to drift mesially a greater distance than the maxillary molar.

The space provided for this late mesial shift is called the "leeway space" of Nance.[31] The mandibular molar has an average leeway space of 1.7 mm on each side, whereas the maxillary molar has but 0.9 mm per side. Thus the mandibular molar can move forward in the arch a greater distance than the maxillary molar, resulting in the late mesial shift from an end-on to full Class I first permanent molar relationship.

At eruption of the mandibular incisors, there is an increase in intercanine distance, due to lateral pressure from the mandibular incisors. In turn, the mandibular deciduous canines being forced laterally place pressure on the maxillary deciduous canines, forcing them laterally. This "secondary spacing"[15] creates more room for eruption of the maxillary permanent lateral incisors.

Once erupted, the mandibular permanent incisors may show some transient crowding. Up to 2 mm of crowding in this area will be reduced completely by age 8 in boys, and reduced to 1 mm by the same age in girls.[26]

On the other hand, spacing exists in the maxillary arch, most noticeably between the central incisors. This "ugly duckling"[11] stage lasts until the maxillary canines erupt, creating sufficient pressure to upright the incisors and close, in the absence of a hypertrophied maxillary labial frenum, the midline diastema.

Canines and premolars erupt in predictable order[22] with variations occurring according to age, sex, and genetic pattern. Girls have on the average 28 of their 32 permanent teeth fully erupted at an earlier age than boys. There are some differences in the eruption order of the succedaneous teeth, the most noticeable being that girls tend to have mandibular permanent canines erupted before eruption of the first premolars, where boys will erupt both at about the same time. In both girls and boys, the maxillary canines are the last maxillary succedaneous teeth to erupt.

Once erupted, all permanent teeth assume a position of equilibrium,[43] supported by the musculature, over basal bone. With continued growth, the incisors tend to become more upright, and the anterior overbite deepens with maturity.[9]

Despite the transient increase in arch length gained at eruption of the permanent incisors, incisor uprighting and molar movement to use the primate and leeway spaces, result in an length discrepancies are only one of the many characteristics of a malocclusion.[1] In addition to arch length (alignment) problems, there may be deviations in the sagittal, transverse and/or vertical parameters, as well as deviation in the soft tissue drape overlying the dental and skeletal systems. The dentist must be able to recognize problems developing in any of these areas, and be prepared to deal with these problems or refer them for treatment.

DEVELOPMENT OF NORMAL OCCLUSION

Dental development begins at 4½ to 5 months *in utero*,[36] starting with the central incisors. During the first three years of life, growth of the cranium is rapid, but even more rapid is growth of the face as it swings itself downward and forward, out from under the cranial base.[11,12]

The deciduous teeth begin eruption about the sixth month,

with all 20 of them fully in place by the third birthday.[37] Measuring from the distal of the second deciduous molar on one side, bucco-lingually through the contact areas in the posterior and along the incisal edges in the anterior, to the distal of the second deciduous molar on the other side, gives the available arch length. From the third year of life to eruption of the full permanent dentition, there is net decrease in the arch length available.[28,38,39]

Given a normal Class I skeletal relationship, two distinct dental patterns are considered normal in deciduous dentition. The first of these presents with congenital "primate spaces"[4] between overall shortening of arch length.[27] It cannot be anticipated, given the weight of scientific evidence to the contrary, that a child with severe dental crowding at age 7 will have anything other than severe dental crowding at age 12.

CAUSES OF ARCH LENGTH DISCREPANCY

In his fine series of articles on Serial Extraction, Dale[15] listed the signs of a true hereditary arch length deficiency. With modification, they are as follows:

1. Premature exfoliation of one or more of the primary cuspids. If only one is lost, the mandibular incisors usually tip laterally toward that space.

2. Crescent shaped resorbtion on the mesial aspect of one or more deciduous canine roots.

3. Lingual displacement of one or both mandibular lateral incisors. If only one is displaced, the mandibular midline will deviate to that side.

4. Labially locked mandibular incisor, usually one of the central incisors, with severe gingival clefting or recession on the labial surface. In cases such as this, repositioning of the incisor over basal bone creates better gingival and bony architecture. It is therefore advisable to postpone gingival grafting procedures until after the tooth has been repositioned.

5. Crowding of the unerupted canines, causing them to bulge to the labial. If allowed to erupt in these labial positions, the result may be a compromise in width of the zone of attached gingiva on the labial surface of these teeth.

6. Splaying of the maxillary and/or mandibular incisors due to the crowded positions of the canines.

7. Ectopic mesial eruption of the maxillary first permanent molar, causing early exfoliation of the second deciduous molar. Failure to treat this condition will result in additional mesial migration of the maxillary first permanent molar, causing eventual impaction of the maxillary second premolar and severe tipping and rotation of the first permanent molar.

8. Vertical palisading of the maxillary permanent first, second and third molars in the tuberosity area.

9. Impaction of the mandibular permanent second molar.

10. Bimaxillary protrusion. Dento-alveolar protrusion in the anterior area, superimposed on a Class I skeletal pattern. This is a crowed dentition in which the teeth do not become crooked, but instead lean forward, cantilevering off their basal bone support.

Not all arch length deficiencies are caused by genetic input. Most of the other causes are neglect on the part of parents, or mismanagement of the part of the dentist. They include:

1. Premature loss of deciduous teeth without benefit of space maintenance. The result is mesial migration of posterior teeth and distal migration of anterior teeth,[32] resulting in additional arch length reduction.

2. Untreated interproximal caries in deciduous teeth. The deciduous teeth drift into each other, flattening the contact areas, reducing arch length.

3. Uneven resorbtion of primary teeth, causing over-retention of the primary teeth and ectopic eruption of the permanent teeth.[23] It has been determined that a permanent tooth will erupt when the root is approximately two-thirds formed. Extraction of the deciduous predecessor, prior to this stage in permanent tooth formation, in the absence of alveolar bone loss due to periapical infection, will not enhance the rate of eruption of the permanent tooth,[17] but will permit a more normal path of eruption.

4. Abberation in the eruptive pattern of the permanent teeth, as in the early extraction of the deciduous canines preventing the formation of secondary spacing in the maxillary lateral incisor areas.

5. Contracted or asymmetrical dental arches. These may be caused by any of a number of abberant functions, such as thumb-sucking, mouth breathing, occlusal interference, *etc*.

6. An anomalous tooth or

teeth, such as overly-large second premolars.

7. Oversized crowns on fractured anterior teeth. There is a strong tendancy, during the ugly duckling stage, for the crowns that are made to be oversized, taking up what is at that time a normal maxillary midline diastema.

8. Overcontoured posterior restorations of interproximal lesions, occluding a portion of the space required for eruption of the succedaneous teeth.

9. Over-retained deciduous second molars in the patient with congenitally missing second premolars.[41]

The causes of arch length excess are, for the most part, the reverse of those for arch length deficiency. It is very rare that a patient presents with even spaces between all of his permanent teeth. More often spacing is caused by: (1) One or more teeth being anomalously small, as peg-shaped laterals. (2) Thick, low maxillary frenum attachment, causing a midline diastema. It must be noted that unless plans are made to close the diastema prior to healing of the frenectomy, scar tissue may form in the operated site, preventing the teeth from being brought together. (3) Abberant muscles function, as a tongue thrust, pushing the incisors forward and causing them to flare. (4) Other habits, such as finger or thumb sucking, causing flaring of the incisors. (5) Loss of posterior teeth with posterior bite collapse and resultant anterior flaring.

The third type of arch length discrepancy is neither deficiency nor excess, but is due to a malrelationship between the sizes of the maxillary and mandibular teeth.[10] The mean value for the relationship between the maxillary 6 anterior teeth and mandibular 6 anterior teeth is that the maxillary 6 anterior teeth are about 27 per cent larger than the mandibular. This creates a normal overbite-overjut relationship in the anterior.

If the maxillary anterior teeth are less than 27 per cent larger than the mandibular, as in the case of peg-shaped laterals, the overbite will be reduced toward zero unless spaces are permitted to exist in the maxillary anterior region.

If the maxillary anterior teeth are more than 27 per cent larger than the mandibular, as in the unfortunate extraction of a labially locked mandibular incisor with severe gingival recession, the overbite will deepen considerably. Unless the maxillary teeth are proportional in size to the mandibular teeth, they will not occlude normally.

MEASUREMENT OF ARCH LENGTH

Determination of arch length discrepancy involves measuring the amount of arch length available, and subtracting from that the amount of arch length required.

Nance[31] suggested the use of a soft brass wire to measure arch length available. By bending the wire, usually .020 in diameter, to conform to the arch form presented by that patient (a form that relates to the underlying basal bone contour), the wire can be laid across the incisal edges of the anterior teeth and over the contact points of the posterior teeth. The wire is then marked at the distal of the second deciduous molar and straightened. The distance between the two marks is the arch length available.

Musich and Ackerman[30] have suggested the use of an instrument called the catenometer to measure arch length available. They found the catenary method considerably more reliable than the brass wire method for making this measurement. The instrument gives a direct reading of the measurement on a Boley gauge.

Other authors[21,33] have suggested the use of calipers or dividers to measure segments of the arch, then adding the segments together to arrive at the measurement for arch length available.

To evaluate arch length required, the mesio-distal widths of all teeth anterior to the first permanent molars must be added together. In the fully erupted permanent dentition, these measurements can be taken directly from the study models.

In the mixed dentition, there are two basic methods available for determining the widths of the unerupted permanent teeth. The first of these is direct measurement of the unerupted teeth on radiographs.[31] It must be noted that to minimize distortion and enlargement, parallel films taken with the long cone technique are preferred. If bisecting angle—short cone films are used, a correction factor must be used to account for radiographic magnification. The use of panoramic x-rays for taking these measurements is strongly contra-indicated,[14,34] again due to distortion of the radiographic image.

The second method is an in-

(continued on page 26)

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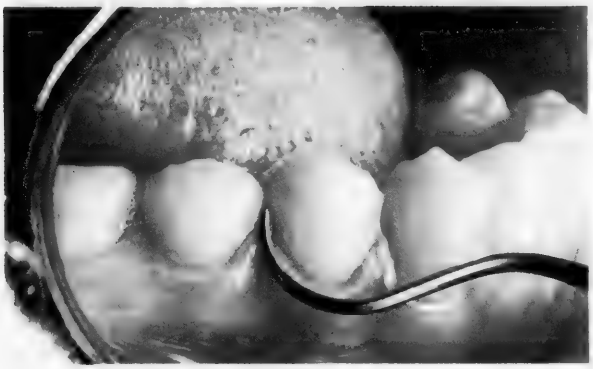

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(continued from page 24)
direct prediction. The incisors are measured, and their widths are fed into prediction table. The table in turn gives the estimated widths of the unerupted permanent teeth.[29,40]

ARCH LENGTH DISCREPANCY

Arch length available minus arch length required equals arch length discrepancy (ALA − ALR = ALD). This resultant sum is the basic information from which arch length is considered. The following adjustments must be considered: (1) Transient increase in arch length available at eruption of the permanent incisor-canine complex. (2) Decrease in arch length as leeway space is used. (3) Uprighting mesially tipped mandibular molars. (4) Relocating the lower incisor over apical base. For every 2.5° the mandibular incisors are tipped to the lingual 1 mm of arch of arch length is required to accommodate them. (5) Flattening the Curve of Speé is required to allow all teeth to properly contact each other. A flat occulsal plane is most receptive to normal occlusion.[2] Approximately three quarters of a millimeter of arch length is required to accommodate each millimeter of bilateral flattening of the curve.

The mandibular arch is the contained arch. It is less amenable to treatment than the maxillary arch. If the mandibular arch length deficiency (ALD), as modified by a variety of factors, is greater than −4 mm, extraction of permanent teeth will probably be necessary. To expand or "develop" the arch beyond this point is to cantilever the teeth off of their basal bone support. This invites either collapse of the arch with recurrence of crowding,[42] or stress and eventual breakdown of the investing and supporting structures of the teeth.[20]

Example

Let's take a look at Johnny, Mrs. Parent's 7-year old with the crowded teeth. Measuring his arch with a catenometer, it was found that Johnny had a mandibular arch length available (ALA) of 63.4 mm. Direct measurement with a Boley gauge of the erupted incisors on the models, and of the canines and premolars on parallel-long cone periapical films, revealed a total mesio-distal measurement of 67.9 mm of arch length required (ALR). Feeding these numbers into the formula ALA − ALR = ALD, we find that Johnny has an arch length deficiency of −4.5 mm. Clearly, room for eruption of the permanent dentition into good alignment, well supported over basal bone, simply does not exist.

But what of the contention that he might grow out of this problem? As his permanent canines erupt, approximately 1 mm of arch length will be gained. The mandibular molars are upright, so no space can be gained there. There will be space loss, approximately 3.5 mm, as leeway space is used. The mandibular incisors are somewhat flared, about 10°, and require 4 mm of arch length to be uprighted. The Curve of Speé was relatively flat, so no alignment was necessary there. With these factors in mind, the −4.5 mm ALD must be modified by adding the plus factors and subtracting the negative. The equation becomes, in this case, − 4.5 mm (ALD) + 1 mm (canine eruption) −3.5 mm (leeway space) − 4 mm (upright $\bar{1}$) = − 8 mm total arch length deficiency anticipated at eruption of the full adult dentition.

This is the rule, to which there is almost no exception. Arch length shows an overall decrease during the transition from the deciduous to the permanent dentition,[25] and continues to do so throughout life.

SUMMARY

From an evolutionary standpoint, our dental arches are progressively getting smaller at a faster rate than our teeth. The overall result is a constantly increasing incidence of dental crowding.

Arch length deficiency is a problem that is recognizable as early as the eruption of the permanent incisors. Accurate means are available for assessing the severity of arch length discrepancy.

If such a discrepancy does exist, it should be evaluated in relation to the skeletal and soft tissue framework as to management of the problem.

The development of a normal full adult dentition is a complex process. Availability of arch length to support the intact dentition is a prime requisite, requiring total understanding of the growth and development process for proper supervision.

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Fluoride Supplements for Infants and Preschool Children

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There is much convincing evidence that fluoride supplements are effective cariostatic agents for children who reside in communities with deficient or sub-optimal levels of fluoride in the drinking water.[1,3,7,12,14–16,21] In the accompanying paper by Parkins[25] it was cited that the majority of studies have reported reductions in the incidence of caries in primary teeth of approximately 50 to 80 per cent when fluoride supplements were begun before two years of age and were continued for at least 3 to 4 years. For permanent teeth, most studies showed reductions of approximately 20 to 40 per cent for children who commenced fluoride supplements between 5 and 9 years of age with at least two to four years of continuous intake.

There appears to be little question that fluoride-vitamin preparations are as effective as fluoride preparations without vitamins.[1,14–16] Combined fluoride-vitamin preparations appear to be more readily accepted than vitamin-free fluoride supplements,[3,9,26] although, unfortunately, such preparations do not permit the desirable adjustment of fluoride dosage without adversely affecting the vitamin dosage.

PREVIOUS RECOMMENDATIONS

The recommendation of the International Workshop on Fluoride and Dental Caries Reduction[11] was that supplementation of fluoride begin as soon after birth as possible and continue through the teenage years. However, there has been considerable controversy regarding the proper dosage to be used and whether it is absolutely necessary to administer supplements from birth in view of the significant post-eruptive topical benefits of fluoride supplements.[4–6,20,23] There is reason to believe that previous recommended dosages may be higher than desirable and may be responsible for the appearance of enamel fluorosis. There is much uncertainty especially in the case of infants and toddlers, as to the dose of fluoride supplement that would achieve maximal protection against dental caries with minimal risk of fluorosis of the enamel.[10]

The Committee on Nutrition of the American Academy of Pediatrics recommends 0.5 mg fluoride per day for children up to age 3 and 1.0 mg daily after age 3 for residents of fluoride deficient communities.[5]

The Council on Dental Therapeutics of the American Dental Association[2] recommends that the prescribed fluoride be adjusted according to the water fluoride concentration. No supplement is required if fluoride in the water supply exceeds 0.7 ppm. For infants, one 2.2 mg tablet of sodium fluoride dissolved in one quart of drinking water will provide fluoridated water that may be used for drinking, preparation of formu-

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las, beverages and infant foods. A satisfactory alternative may be the use of 0.25 mg fluoride per day. For children between two and three years of age, a tablet containing one mg F may be given every other day, or half a tablet be given daily.[2]

In communities with essentially no fluoride in the water, a 1 mg fluoride tablet (2.2 mg NaF) may be prescribed for the child three years or older. A slightly more conservative dosage schedule had been suggested by Nikiforuk and Frazer as early as 1964.[24]

In view of many observations that enamel fluorosis may occur following fluoride supplementation,[1,13,17] a careful reexamination of the recommended dosage is in order, especially due to the fact that 0.5 mg per day for under 3 years of age is still the dosage most commonly recommended by drug manufacturers.

Many investigators who have used fluoride supplements have not reported any "objectionable" fluorosis probably because primary teeth are apparently less prone to show fluorosis despite high levels of fluoride intake,[8] and due to the subjective method of assessment of fluorosis, many of the very mild to mild categories of enamel fluorosis might have been overlooked or underestimated.[12,13] On the other hand, Aasenden and Peebles[1] reported an alarming 67 per cent of children on fluoride supplements as having fluorosis of the permanent teeth mainly of the mild to very mild type. Fourteen per cent of these children were in the moderate category but no discoloring or pitting of the enamel was seen. The authors concluded that the dosage of fluoride supplements given were higher than the amount ingested by drinking fluoridated water and that the doses of fluoride given during the first year of life were at the very borderline of the tolerable limit. They further recommended that consideration be given to reducing the dose before age 3 and increasing the dose after the age of 5 to 6 years when formation of the crowns of the anterior teeth is almost complete.

Hotz[17] reported similar observations of mild enamel fluorosis in Switzerland when children were supplemented at 0.5 mg fluoride from birth to age four and 1.0 mg thereafter. Consequently, the Swiss have modified their dosage as follows:

Age	Fluoride (mg)
0–2	0.25
2–4	0.50
4–7	0.75
>7	1.00

Table 1. Recommended Fluoride Supplementation.

F Concentration of Water Supply (PPM)	Desirable Fluoride Supplementation (mg/day)			
	0–6 mon	6–18 mon	18–36 mon	3–6 yrs
<0.2	0	0.25	0.50	.75
0.2–0.4	0	0*	0.25	.50
0.4–0.6	0	0*	0	.25
0.6–0.8	0	0*	0	0
>0.8	0	0*	0	0

* 0.25 mg for breastfed infants between 6 and 12 months of age.

NEW RECOMMENDATIONS

Information from many sources[11,18,19,30] suggests that previous recommendations for fluoride supplementation of infants and small children may have been greater than desirable.

Fomon and Wei[10] have recommended that no supplements be used during the first 6 months of life, a maximum dosage of 0.25 mg daily between 6 and 18 months, 0.5 mg daily between 18 and 36 months and 0.75 mg daily between 3 and 6 years of age (Table 1).

Birth to Age 6 Months: It had previously been assumed that infants living in communities with sub-optimal drinking water, and those who are breastfed or fed whole cow's milk would be likely to receive inadequate amounts of fluoride daily.[27,29] However, recent data suggest that infants may receive more dietary fluoride than was previously thought. Infante[18] estimated that the recommendation of 0.5 mg F per day may be 2–6 times greater than desirable.

Wiatrowski, and co-workers[30] studied the dietary intake of fluoride in infants from one week to 6 months. Their estimates showed that infants 1–4 weeks of age received 0.32 mg per day from a formula preparation containing 0.5 mg/ml. Tinanoff and Mueller[28] measured the fluoride concentration of various formula preparations, cow and breast milk and found variations of fluoride concentrations from 0.10 to 0.85 ppm.

The fluoride content of commercially prepared concentrated liquid formulas may vary widely even among products produced by the same manufacturers. A concentrated liquid formula made from liquid fat-free milk does not require addition of water and will have a low fluoride content. However, with formulas made from dry ingredients, the manufacturer adds water from local water supplies which may or may not be fluoridated. Because a manufacturer may market a product of the same name produced in plants in different cities, it is apparent that the physician may not know the fluoride content of the feeding he recommends.[10]

Whether an appropriate single daily dose of fluoride beginning at birth confers significantly greater protection against dental caries than does an appropriate single daily dose of fluoride beginning at age 6 months is currently unknown. In view of this uncertainty and the extreme difficulty in defining an appropriate daily dose of fluoride for infants less than 6 months of age, it seems desirable at present to delay fluoride supplementation to age 6 months (Table 1).

Six Months to Three Years: Because of the possibility that infants may receive greater intakes of fluoride from various foods than was previously assumed[30] the fluoride dosage of 0.5 mg daily recommended previously may be too high.[5,29] Aasenden and Peebles[1] have shown that children living in a community with low fluoride concentration in drinking water who received a supplement of 0.5 mg of fluoride daily from birth to 3 years and 1 mg thereafter resulted in mild fluorosis of 67 per cent of the children. Therefore, a maximal daily dose of 0.25 mg of fluoride is recommended for individuals between 6 and 18 months of age (Table 1). The dose is increased to 0.5 mg between 18 months to age three.

Children Over Three Years of Age: As indicated in Table 1 older preschool children and school-age children should also receive fluoride supplements in relation to the fluoride content of the drinking water. By age 6, the total daily fluoride may be increased to 1 mg. Beyond age 6, the main beneficial effects of fluoride tablets appear to be topical and the risk of enamel fluorosis is negligible. Details of supplementation from age 6 through the teenage years have been discussed in the accompanying paper by Parkins.[25]

SUMMARY

The efficacy of fluoride supplements in suboptimally fluoridated communities has been convincingly demonstrated by a large number of clinical studies. There appears to be a significant post-eruptive topical effect of fluoride tablets in addition to systemic benefits.

There is much controversy about fluoride supplements for infants and toddlers particularly because recent studies have reported a high prevalence of enamel fluorosis mostly of the mild type when the previously accepted schedules of recommendations were followed. More conservative and rational schedules for infants, and the preschool and young child have been suggested. These tables may require modifications as additional evidence becomes available.

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(continued on page 32)

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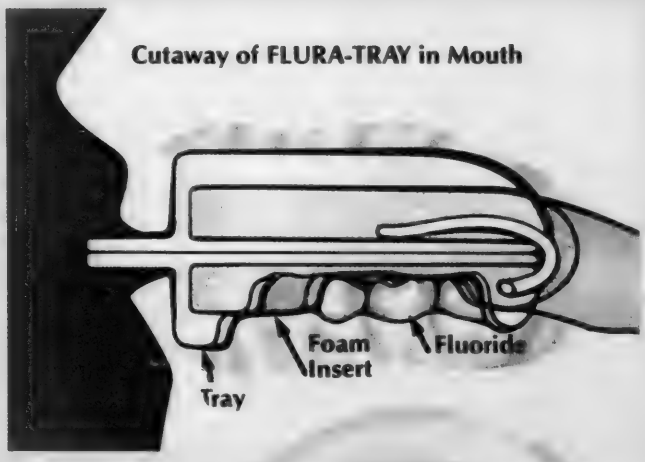

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(continued from page 30)

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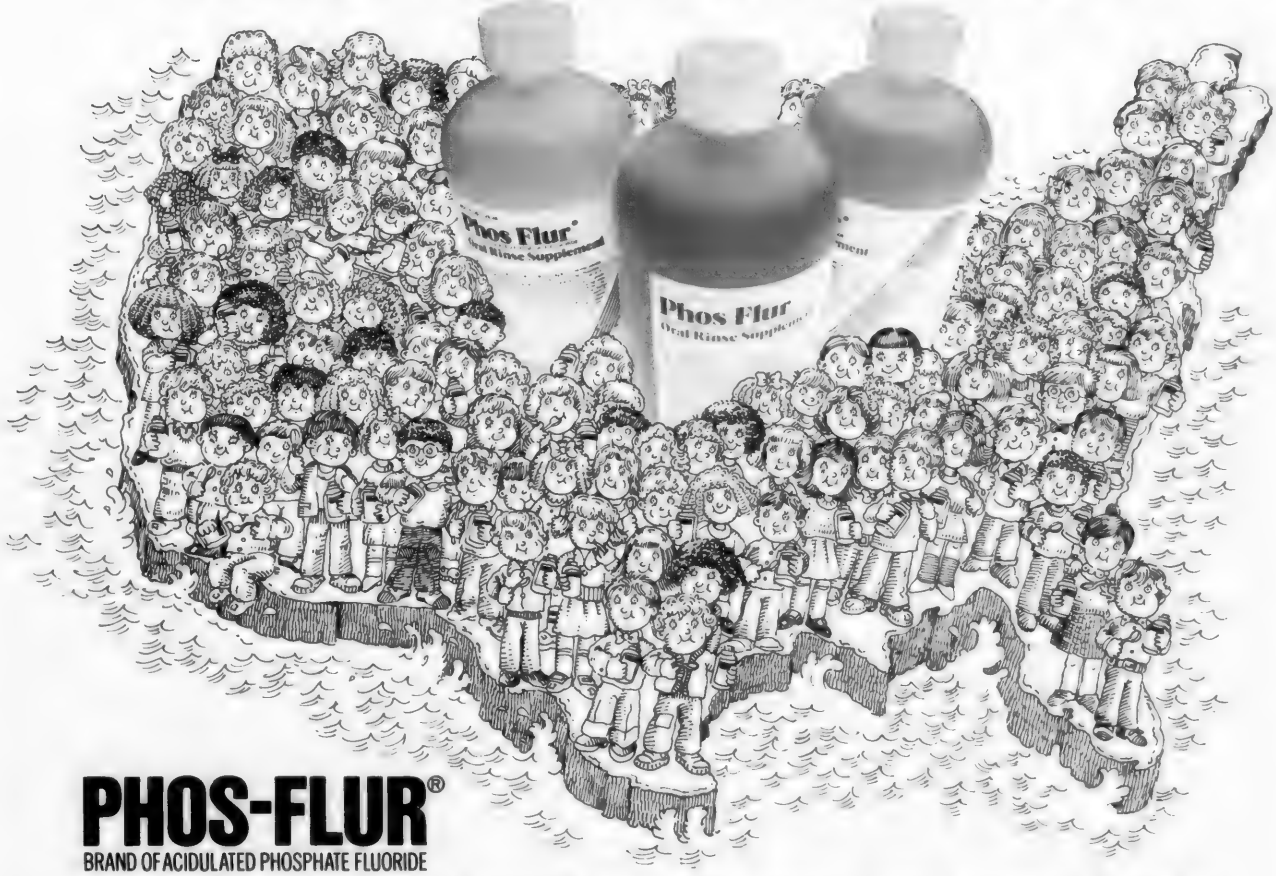

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Psychological and Chemical Mediators of Gingival Health. See page 6

☐ Psychological and Chemical Mediators of Gingival Health
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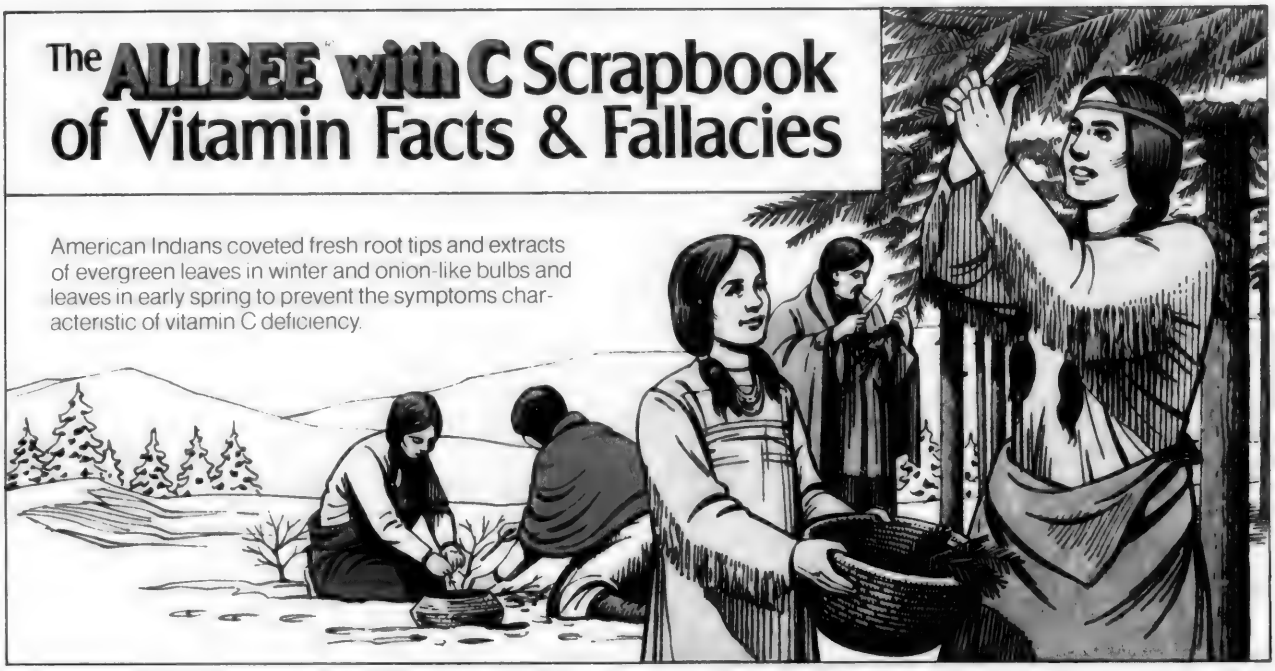

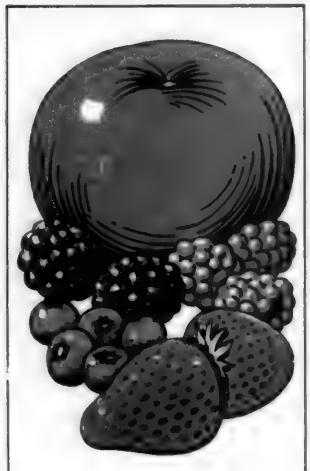

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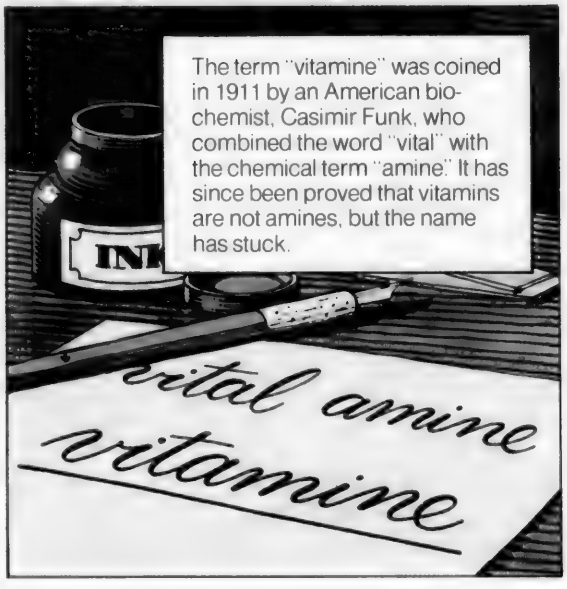

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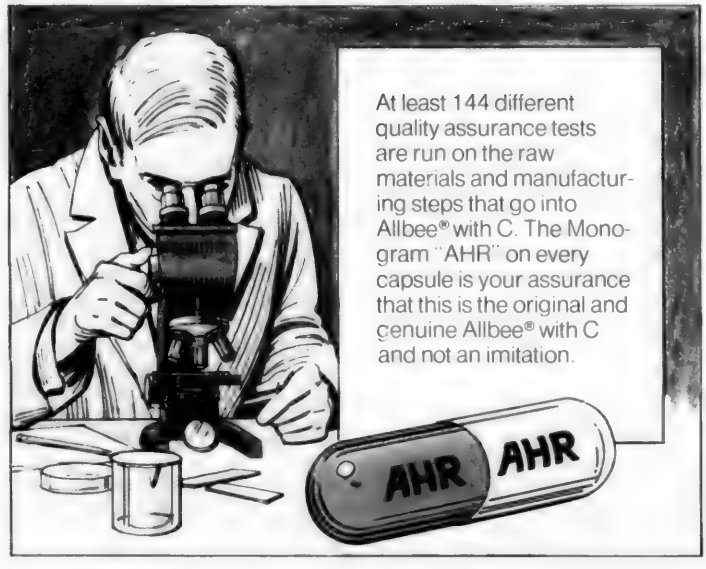

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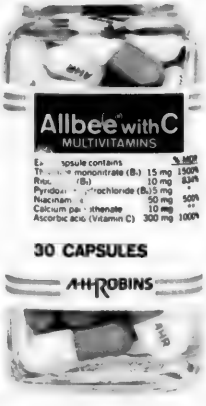

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contents

5 Preface

Hans R. Mühlemann, Prof. Dr. Med.

6 Psychological and Chemical Mediators of Gingival Health

Hans R. Mühlemann, Prof. Dr. Med.

20 Patient Motivation with the Papillary Bleeding Index

U. P. Saxer, B. Turconi, and Ch. Elsasser

25 Topical Fluorides in Dental Practice

Stephen H. Y. Wei, D.D.S. and James S. Wefel, Ph.D.

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Preface

Hans R. Mühlemann, Prof. Dr. Med.*

Once again I have been offered the privilege of guest editing an issue of the *Journal of Preventive Dentistry*. As in the April 1977 issue, I was fortunate to be assisted by several staff members in compiling the following reports.

In the first paper, I have analyzed "The Psychological and Chemical Factors Involved in Gingival Health". The presentation begins with a critical evaluation of how failures of present-day psychological mediation of gingival health could be overcome in the future. The concept of the Dental Troika is postulated. A language understandable to the patient, the dentist and the third party is possible if the most frequent symptom of chronic oral disease, "gingival bleeding", is adequately defined and used. In the future the bleeding symptom will probably play an increasingly important role in periodontology and cariology. The paper by Saxer, Turconi and Elsässer: "Patient Motivation with the Papillary Bleeding Index" demonstrates my article's clinical relevance.

The use of chlorhexidine, a chemical mediator of gingival health and probably also a factor in preventing the progression of periodontal disease, has become common practice in many European countries. The benefits for the individual are overwhelming when compared to its side effects.

Recently, a new class of potential mediators of gingival health, several anti-inflammatory non-steroid compounds, have been tested in Zurich. In general they have failed to show relevant antiphlogistic effects. Other chemical antagonists of inflammatory gingival disease are also discussed by Mühlemann.

I will be surprised if the two Issues I have had the pleasure of editing are not provocative. If they are not, they have missed their goal of stimulating the preventive dentistry community: clinicians, their various auxilliaries and the scientists who all firmly believe in the tremendous potential of improving oral health by an intelligent and unified approach. International stimulation should help to achieve this earlier and more elegantly. I am grateful to the Editor, Dr. H. Brilliant, for having considered a dental team abroad.

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Psychological and Chemical Mediators of Gingival Health

Hans R. Mühlemann, Prof. Dr. Med.*

There is universal agreement that freedom from microbial dental plaque is synonymous with gingival and dental health. Total plaque removal for several consecutive days will transform inflamed gingivae into clinically healthy structures. Even in advanced cases of inflammatory periodontal diseases, daily mechanical and chemical reduction of the marginal microflora will attenuate exudation from periodontal pockets dramatically, and have definite anti-inflammatory effects on the periodontium.

What is the impact of these known scientific facts on preventive care by the *public* and by *individuals*? How is their behavior pattern changed by new knowledge? Epidemiological studies in Switzerland[14,15] and in many other countries have shown that public gingival health (in adults) has improved little during the last two decades. Simple widely accepted plaque removing methods are not used by the majority of the Swiss population.[38,47] Only 4.2 million toothbrushes are sold yearly in Switzerland; the projected number necessary for proper oral hygiene is 18 million. Only five to ten per cent of the Swiss communities provide adequate preventive programs for school children; such programs could reduce costs of school dental services by 50 to 75 per cent.[35] Reasons for such failures are not due to a lack of information, but rather to both inadequate motivation by dentists and governmental authorities, and a failure to change the population's poor habits into modern, more efficient ones.

Today, relevant improvement of oral hygiene on a *public health level* remains an utopian dream. It is highly improbable that better hygiene will ever be achieved by changing the free behavior of masses. History repeatedly has shown that whole populations can easily be motivated by simple hedonic information, such as spending more time watching TV when Muhammed Ali, olympic athletes or baseball players perform. Masses can be motivated and manipulated into aggressiveness and killing. But motivation for prevention of lung cancer, cardiac infarction or changing habits to achieve oral health is another issue. The public, despite considerable material and psychological investments, continues to smoke, gain weight, eat candy, lose teeth, become edentulous and take health risks in many additional areas.

In a two-year clinical study by the Institute for Preventive and Community Dentistry in Nijmegen[33] with almost 1000 children, dental health was not improved by providing sporadic information and motivation with rewards. The authors concluded that new kinds of motivation were necessary.

PSYCHOLOGICAL MEDIATORS OF GINGIVAL HEALTH

It is our opinion that future endeavors to improve the oral *hygiene of masses* is less a matter of additional support of psychological research programs than an attempt to develop new mechanical and chemical plaque removing techniques freely accessible to the public and economically feasible. Preventive oral medicine[25] has been slightly more successful in *individual* gingival health programs. Scientists and dental practitioners agree that the participation of the individual in a new health education program is attractive and therefore good in its initial stage; it will, with the majority of patients, become poor after a few months and, therefore, will need continuous reinforcement in order to change poor old habits. The psychology of the patient-dentist relationship has been discussed in detail by Barkley,[5] Lefer[22] and Spaan.[46] The technical armamentarium for obtaining and maintaining oral health has been greatly improved during the last 20 years. Better instructional audiovisual aids have also been developed.[2]

Today, office patients still are preferentially motivated by focusing their attention on the uncleanliness of teeth by 1) disclosing bacterial deposits, the cause of disease, 2) phase microscopy of the microcosm and 3) plaque scoring. Professional resistance to the participation of auxiliaries in organ-

Table 1. Frequencies and Averages of Gingival Inflammation.*

	Day					
	0	3	6	10	13	17
SB scores						
0	738	749	507	388	298	264
1	88	81	292	386	438	470
2	6	2	32	58	93	89
3	0	0	1	0	3	9
Average +	0.12	0.10	0.43	0.60	0.76	0.81
Stand. dev. (64 gingival units per subject)	0.17	0.07	0.36	0.19	0.17	0.14
Average gingival fluid flow rate +	0.49	0.97	1.19	1.17	1.26	1.64
Stand. dev. (6 samples per subject)	0.31	0.24	0.21	0.21	0.18	0.28

* Sulcus bleeding scores (SB) and average of gingival fluid flow rates at the beginning and during the 17-day no hygiene period (13 subjects). From Mühlemann, H.R. and Son, S.: Gingival Sulcus Bleeding—a Leading Symptom in Initial Gingivitis, Helv. Odont. Acta 15, 107: 1971.

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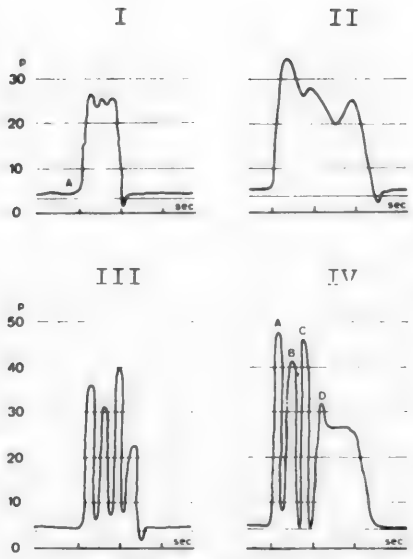

FIG. 1. Probing force patterns of four investigators (I–IV). Recordings with a pressure-sensitive periodontal probe. Investigator I: Relatively constant force for less than 1 sec. II: The probe was inserted, then guided mesially and distally within the sulcus for 2–3 sec. III and IV: Series of probe insertions. Due either to tooth morphology, or to tooth surface roughness, or to gingival contour and consistency, or to probe position; it is often difficult to gain entrance into the sulcus. In positions A, B and C several attempts were made with relatively high forces. In position D the tip gained entrance with less force. (Helv. Odont. Acta 15, 114, 1971).

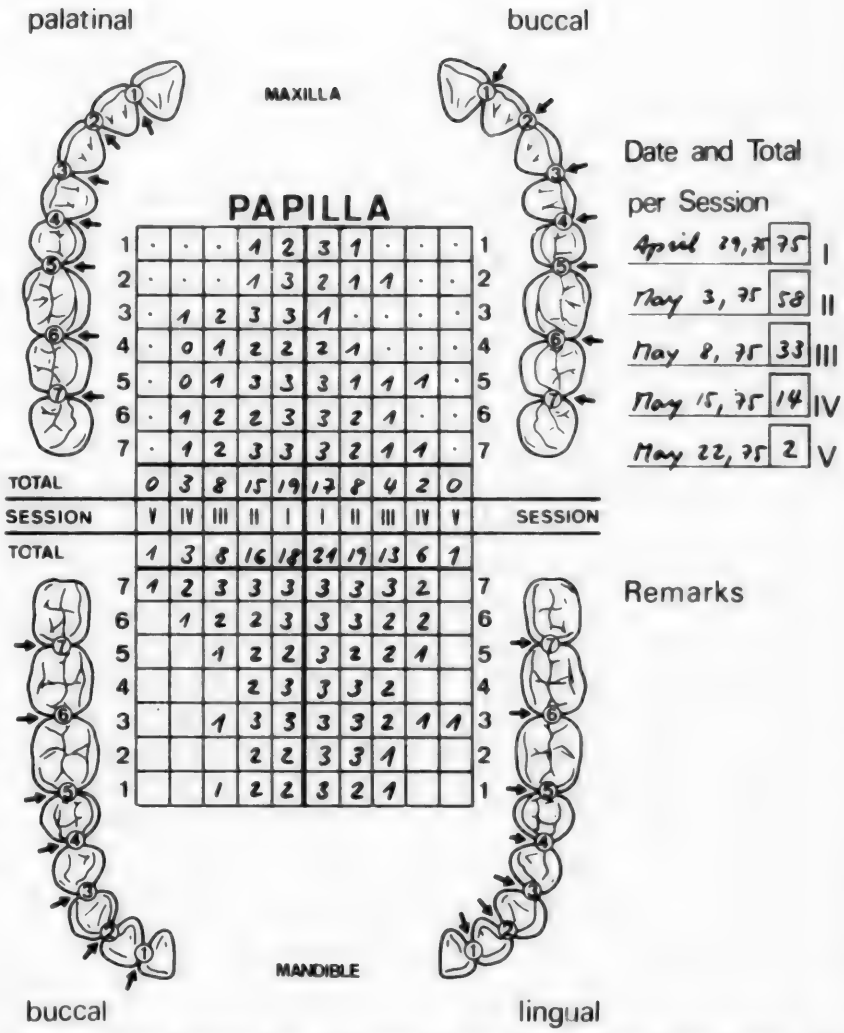

FIG. 2. Papillary Bleeding Form. The scores are entered at each oral hygiene session. The total of the scores for the four quadrants is recorded on the right with the date of each session (I–V). The severity of bleeding was reduced from 75 to 2 in 3 weeks.

ized professional plaque control programs has gradually decreased in Europe. Nevertheless, the quality of health information and motivation to change habits still needs much improvement.

The Dental Troika

Due to the rather modest success rates in the long range cooperation of patients, other motivational approaches to attain oral health should be investigated more thoroughly. Patients (often unconciously) do not appreciate scientific demonstrations of the lack of cleanliness in their mouths. Intimidation and/or punishment for oral neglect is not an appropriate tool to enhance cooperation with the dentist. The never-ending challenge of the patient to comply with professional recommendations is too much of a unidirectional, onesided act. Preventive care is not only the patient's responsibility and duty; the patient should also have the right to make demands. Successful motivation for efficient oral hygiene habits is based on the coordination of rights and duties of *three parties* simultaneously interested in reaching gingival health—*the patient*, *the dentist* and in many countries *social security* or *health insurance*. This is the dental troika. In a modern motivational situation, the Dentist, the Patient and the *Third Party* should each have the right to challenge the other. The involvement of the Troika in attempting to attain gingival health necessitates a simple and reliable definition of gingival disease, understandable by all three parties.[38]

Diagnosis of Gingival Disease

Bleeding is a symptom of disease in all parts of the body. The gingival bleeding symptom is unequivocal to the dentist, patient and even the insurance administrator; it is in contrast to defining gingival disease by such vague terms as redness or swelling. Bleeding from the gingival sulcus, as a response to gentle probing, was first used as a parameter of gingival disease by Mühlemann and Mazor.[27] A clinical test[29] in 1971 showed the *Sulcus Bleeding Index* to be more sensitive than other gingival disease scoring systems.

In this study, 13 young adults refrained from all oral hygiene measures. At the start (Table 1) of the non-

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PATIENT EDUCATION CHECK

Please answer the following statements to the best of your knowledge by circling + (= Yes) or - (= No). Do not hesitate to answer "No" if applicable! If you cannot answer cross out the question. With your signature below you are accepting full responsibility for your answers.

I know that the gum between the teeth is called "papilla"	+ -	I know that the hygienic condition of teeth and gums can best be checked in an illuminated enlarging mirror mounted on the wall	+ -	I have been told to see the dentist if I develop a clenching or grinding habit	+ -
I know that bleeding papillae indicate gum disease	+ -	I have been shown in mirror that a periodontal file can pass easily between my teeth and that all interdental surfaces of my crowns and fillings are smooth and even	+ -	ANSWER THE FOLLOWING QUESTIONS ONLY IF WEARING A REMOVABLE PLASTIC BRIDGE	
I know that healthy papillae do not bleed on probing with a tooth pick	+ -	I have been shown the daily cleaning procedure on interdental surfaces adjacent to bleeding papilla	+ -	I know that the abutment teeth of my removable plastic bridge must be kept exceptionally clean by conscientious plaque removal	+ -
I know that bleeding gums are caused by an accumulation of bacteria on teeth (dental plaque)	+ -	I know what a "periodontal pocket" is	+ -	I know that the gum collar of such abutment teeth must be cleaned-out daily with a round tooth pick, in order to avoid bleeding	+ -
I know that gum bleeding can be cured by means of daily plaque removal with tooth brush, dental floss or tooth pick	+ -	I know how to "clean-out periodontal pockets" with a round tooth pick	+ -	I know that my plastic bridge must be removed for cleaning twice daily, in order to avoid bleeding	+ -
I know how to use a disclosing agent to make bacterial deposits visible on teeth and gums	+ -	I know that sucrose injures the teeth	+ -	I have been shown how to fill my removable bridge prior to insertion with a disinfectant gel	+ -
I have been told to spend daily as much time for oral hygiene as is necessary for complete removal of plaque	+ -	I know that frequent consumption of sugar throughout the day is more dangerous than for instance eating twenty sugar cubes all at once	+ -	I have been shown how to clean the removable bridge	+ -
I know that I should see the dentist if I cannot stop papillary bleeding in spite of daily plaque removal	+ -	I know about sugarfree sweets that do not promote tooth decay	+ -		
I know what a "periodontal file" is	+ -	I am aware of the destructive potential of tooth clenching and grinding	+ -		

DO NOT FORGET TO SIGN THE DOCUMENT

Date:

Signature:

FIG. 3. Patient Education Check. The patient completes the form by circling + or --.

hygiene period there were 738 non-bleeding, healthy units; 88 units had bleeding points on gentle probing and only six showed bleeding plus slight changes in gingival redness. At the end of the test, on day 17, 470 units were bleeding but only 89 showed abnormal redness. Scoring inflammation as recommended in the Scandinavian Gingival Index System[24] only 11.9% of the healthy units at risk received scores that indicated disease. Bleeding from the gently probed sulcus preceded the appearance of gingival color changes.

Bleeding is the leading and first clinical symptom of marginal gingivitis and papillitis. It is possible to encounter discolored units which do not bleed upon probing, especially marginal units in children. These are scored in the SBI-System as noninflamed (score 0). The average forces exerted during "gentle" probing of the sulcus were found to range in eight investigators between 20 and 33 pounds. Tooth form and position both affect probing forces[17] (Fig. 1). Interinvestigator discrepancies and correlations between probing force and recorded depth have been reported.[19]

The *Papillary Bleeding Index*,[38] recently introduced for assessing preventive care by periodontal patients, is an excellent indicator of the shift from gingival disease to gingival health as a consequence of interproximal plaque control by the individual (Fig. 2). The Index simply scores the presence or absence of papillary bleeding. Sulcus probing with a periodontal probe by the dentist or with a tooth pick by the patient will also distinguish the severity of bleeding and can be categorized as shown in Table 2. These scores are entered in the "Papillary Bleeding Form"; the decrease in disease severity and frequency can then be followed from session to session (Fig. 2). Reduction of bleeding points upon probing was also used by Lennox and Kopczyk.[23] Furthermore, to evaluate oral hygiene performance by the patient, instead of probing, unwaxed floss was used interproximally by Carter and Barns.[12] The presence or absence of disease was thereby detected using bleeding as a sign of disease. In a study on 101 school children[42] flossing the interproximal area proved to be more sensitive in diagnosing papillary bleeding than probing with the Noetzli-Plast-O-Probe.[40] At the beginning of the study only one child had no bleeding points when flossing. Edwards[16] recommended the use of interproximal tape instead of floss to accomplish this end. Ainamo and Bay[1] also reported on sulcus probing and bleeding in assessing oral hygiene progress.

Table 2. Scores of Papillary Bleeding Index*

Score	Bleeding on Gentle Probing
0	No bleeding
A	Only one bleeding-point appearing
B	Several isolated bleeding-points or a small single blood area appearing
C	Interdental triangle filled with blood soon after probing
D	Profuse bleeding when probing, blood spreading towards the marginal gingiva

* From Saxer, U. and Mühlemann, H.R.: Motivation und Aufklärung. Schweiz. Mschr. Zahnheilk. 85, 905: 1975 (with recent modifications).

Claims of the Patient

If papillary bleeding in a plaque removing program disappears in some but not in other papillae, then the presence of interproximal irritants is highly probable. The patient then should challenge the dentist, who should examine the interproximal area with dental floss, periodontal files and radiographs. In this department a system, the "Patient Education Check", permitting reciprocal checking, is used. The dentist will know whether or not the patient is cooperative, and the patient will come to know whether the restored interproximal areas are smooth and free from iatrogenic irritants. The form is represented in Figure 3. The patient has to fill in the form and answer "yes" or "no" to 19 questions. One of these will protect the dentist from false claims that could be made by the patient if bleeding does not disappear: "I have been shown in the mirror that dental floss or a periodontal file can pass easily between my teeth and that all interdental surfaces and borders of my crowns and fillings are smooth and even." Under such irritant-free conditions, plaque removal in most cases with floss or tooth pick is possible. If bleeding still persists, it is most probably due to inadequate cooperation or techniques of the patient. In the future this perhaps will be of decisive importance to those financing professional dental care. A further "Oral Examination Check" may also become an important document to all members of the Troika (Fig. 4). The form is completed at the end of the treatment period, when two bite wing radiographs are made. The number of remaining bleeding papillae is indicated as is the intensity of bleeding. The absence of occlusal interferences is also recorded. In time, the administrator representing the public health service, social security or private health insurance will become increasingly interested in preventive programs that up to now have been rather enigmatic to the patient as well as to the administrator. In summary, important psychological mediators of gingival health are: 1) Acceptance of the dental troika philosophy. 2) Acceptance of gingival bleeding as the simple and objective symptom of gingival and periodontal disease. 3) Use of the "Patient Education Check." 4) Use of the "Oral Examination Check."

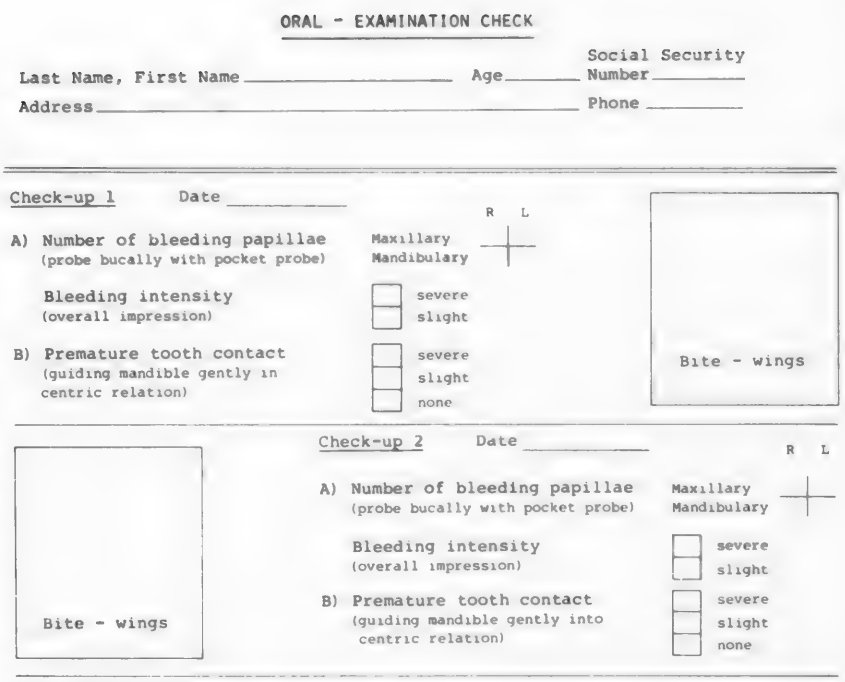


FIG. 4. The "Oral Examination Check" is completed at the termination of a treatment period. The form must include bite wing radiographs.

Table 3. Plaque Reduction by One Week Rinsing with Hibitan® and Plak Out®*

		Plaque Index Silness-Loe[24]	Sulcular Plaque Index Mühlemann-Strub[25]
Hibitane*			
0.2% aqueous	Before	1.65 ± 0.72	70 ±30
Rinsing solution	After	0.44 ± 0.27	47 ± 34
N = 13			
Plak Out®			
Chlorhexidine	Before	1.63 ± 0.75	66 ± 33
Digluconate	After	0.60 ± 0.52	43 ± 30
(Diluted concentrate) N = 12			

* From Saxer, U. and Linden, A.-M.: Antiplaque effects of a 0.2% aqueous Hibitane solution and of an alcoholic 10 per cent concentrate diluted to 0.2% prior to use. Helv. Odont. Acta in: Schweiz. Mschr. Zahnheilk. In preparation.

Table 4. The Effect of Chlorhexidine-dichloride Lozenges on Plaque Formation, 7 Day Non-hygiene Period*

Lozenge		Plaque Index Silness-Loe[24]	Sulcular Plaque Index Mühlemann-Strub[25]
Chlorhexidine	Begin	0.06 + 0.08	1.92 + 2.16
Dichloride	End	2.00 + 0.65	90.88 + 9.81
Placebo	Begin	0.07 +0.09	0.86 + 2.15
	End	1.99 + 0.57	95.05 + 6.43

* From Saxer, U.: Lack of Antiplaque action of Chlorhexidine Lozenges (In preparation).

Table 5. Water Solubility of Inorganic and Organic Salts of Chlorhexidine* (per cent)

Base	0.008	Benzoate	0.03
Gluconate	70	Monoglycolate	0.08
Acetate	1.8 (0.2 in C_2H_5OH)	PO_4	0.03
Lactate	1.0		
Fluoride	0.5	MFP	0.03
Jodide	0.1	NO_4	0.03
Chloride	0.06 (6.0 in C_2H_5OH)	SO_3	0.02
Perchlorate	0.1	SO_4	0.01
Tartrate	0.1		

* In part from *Senior*: J.Soc.Cosm.Chem. 24, 259, 1973.

Table 6. Oral Fluoride Retention After F-Rinses (250 ppm)*

F-Rinse 15 ml	No. Subject	Duration Rinse sec	Volume Expectorate	F-Retention µg
NaF	30	15	97	343 165
AmF**	30	15	105	410 136
AmF**	30	30	109	563 160

* From Mühlemann, H.R. and Rudolf, E.R.: Fluoride Retention after Rinsing with Sodium Fluoride and Amine Fluoride. Helv.Odont.Acta 19, 81, 1975.
** Cetylamine·HF/oleylamine·HF.

Table 7. F-Concentration in Whole Saliva Samples One to Ten Minutes after Various Rinsing Sequences*

Rinse and Rinse Sequence	First Rinse	Second Rinse	F-Content ppm 1 min	5 min	10 min
Cetylamine·HF Oleylamine·HF	= AmF		83	37	14
Sodium fluoride	= NaF		66	20	8
Cetylamine·HCl Oleylamine·HCl	= AmCl	– AmF	64	16	8
Na laurylsulfate		AmF	61	22	9
Na laurylsulfate		AmF	70	20	9

* From Mühlemann, H.R. and Rudolf, E.R.: Fluoride Retention after Rinsing with Sodium Fluoride and Amine Fluoride. Helv.Odont.Acta 19, 81, 1975.

CHEMICAL MEDIATORS OF GINGIVAL HEALTH

Gingival health in the future may be achieved by various chemical mediators. In principle these mediators can be classified into *antiplaque agents* which interefere with the cause of gingival disease (inflammation) and *antiphlogistics* (anti-inflammatory agents) which interfere with the complex chemistry of initial and established gingival inflammation.

Antiplaque agents are (1) *disinfectants* which inhibit microbial life rather unspecifically. (2) *Antiglycolytic agents* which interfere more specifically with energy production by dental plaque. This may, in turn alter: a) synthesis of protein (growth of plaque), cell walls, or b) synthesis of bacterial enzymes such as proteases, collagenase, hyaluronidase, glucuronidase, phosphatases, glycosyltransferases, etc. Retention of these agents by plaque or *plaquophilia* of agents is necessary for such action. (3) *Anticolonization agents* which provide *plaqueophobia* to the enamel surface and thus inhibit the establishment of plaque. (4) *Antimetabolites* which react with or neutralize phlogogenic metabolites of plaque, such as antiendotoxins and antichemotactic agents.

Antiphlogistics include *epitheliotropic agents* providing maximal maturation and resistance of the junctional epithelium against the damaging influences of plaque. A potential agent is vitamin A. *Inhibition of metabolites* causing inflammation, such as endotoxins, chemotaxins, mediators of humoral and cellular immune responses, of degranulation, and of changes in vascular permeability etc.

At present this classification of gingival health mediators is rather theoretical in nature. However it should stimulate oral pharmacologists to use various new approaches in the development of chemical mediators of gingival health.

Antiplaque Agents

Present motivation methods to improve gingival health need chemical reinforcement in order to successfully retard plaque build up. Chlorhexidine preparations are available on prescription in many European countries. It is evident from the demand that they have become a very valuable aid in treating individuals with juvenile periodontitis, severe progressive periodontal destruction and desperate periodontal problems in patients with extensive fixed prosthetic appliances. Chlorhexidine has also been useful in treating handicapped and mentally retarded children.[6]

Among the antiplaque agents the cationic disinfectants have revolutionized the fight against plaque diseases. Chlorhexidine has been shown to have antiplaque action because of its affinity to dental plaque and to mucin layers covering the oral mucosa. This chemical retention provides long lasting antiplaque action in contrast to a simple short lasting depression of the salivary microflora by classical disinfectants. Also, it has provided much relief to patients suffering from X-ray xerostomia. It is also indicated in the initial treatment of rampant caries and acute necrotizing ulcerative gingivitis.

Various dosage forms of chlorhexidine are available including gels and rinses. If chlorhexidine gels are used they should be mechanically retained in the infection area because chemical retention of chlorhexidine by mucin is slightly impaired with some gel formulations. This point was demonstrated by Hansen, Gjermo and Erikson[18] who reported that brushing once a day with a one per cent chlorhexidine containing gel had no effect on gingivitis.

The taste of chlorhexidine has been objectionable to many patients. It has been possible to achieve compatibility

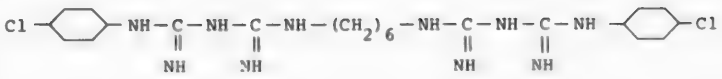
of aromatics and taste modifiers with solutions of chlorhexidine digluconate. Saxer[39] has reported on the effects of chlorhexidine digluconate (Hibitane®) and of an artificially sweetened 10% alcoholic concentrate of chlorhexidine-digluconate diluted with water prior to rinsing (Plak Out®).* His findings are summarized in Table 3. The two rinses were comparable in reducing established plaque scores. However, the artificially sweetened rinse was more acceptable to the patients.

Plaque inhibition is also dependent on the solubility of the chlorhexidine salts. Saxer[37] has compared the plaque inhibitory action of lozenges containing chlorhexidine-*chloride* and of corresponding placebo lozenges. The subjects were sucking four lozenges (5 mg each) per day, thus introducing a total of 20 mg chlorhexidine-chloride into the oral cavity. This corresponded to approximately 20 ml of a 0.1% Hibitane® solution (chlorhexidine gluconate) used over a period of one day. Although it has been shown repeatedly that daily rinsing with this solution inhibits plaque formation to a clinically relevant extent,[32] chlorhexidine-chloride lozenges on the other hand were without significant effect on plaque formation compared with placebo lozenges (Table 4).

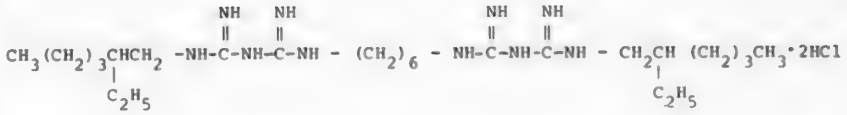
The water solubility of chlorhexidine-chloride is only 0.06% (600 ppm). Five milligrams of this salt introduced into the oral cavity will dissolve only gradually, will be diluted continuously and will be swallowed. Important plaque inhibitory concentrations are probably never reached with this mode of administration. The solubilities of chlorhexidine salts have been assembled by Senior.[43,44] Part of this report is presented in Table 5.

Many inorganic as well as organic chemicals form relatively insoluble salts with the highly soluble gluconate of chlorhexidine. High concentrations of benzoates, cinnamates, phosphates, fluorophosphates, sulfates, sulfites, nitrates etc., in oral preparations can precipitate and thus inactivate soluble chlorhexidine-gluconate. Inhibition of antiplaque effects of chlorhexidine is probably produced by blocking the anionic sites which bind chlorhexidine electrostatically and also by H-bonds to the salivary mucins covering the oral mucosae. These sites are operative in chlorhexidine retention. The blocking of acid anionic receptors, such as carboxyl groups, sulfates or phosphates of salivary glycoproteins has been discussed by Rölla and Melsen.[36]

Hibitane



Alexidine



Vantocil

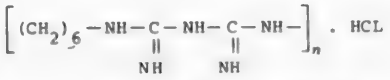


FIG. 5. Molecular formulae of Hibitane®, Alexidine® and Vantocil®.

Indirect evidence confirming such a mechanism has also been obtained when comparing the oral fluoride clearance of inorganic fluoride with cationic amine fluorides[28]: Fluroide retention in the oral cavity from an amine fluoride rinse (solution of cetylamine.HF 1 part, oleylamine.HF 1 part, 250 ppm F, 15 ml, 15 sec) was 20% higher compared with a sodium fluoride rinse of identical F-content (Table 6).

The fluoride content of collected saliva samples was significantly lower ten minutes after rinsing with sodium fluoride than with amine fluoride. Prerinsing with anionic sodium lauryl sulfate or with cetylamine chloride diminished the F-clearance superiority of cetylamine fluoride over sodium fluoride (Table 7). Loss of increased retention of amine fluoride was explained by competitive blocking with amine chloride of amine receptor sites.

Alexidine® and *Vantocil*® (Fig. 5), a polymeric hexamethylene-biguanide devoid of the chlorophenol groups present in chlorhexidine are biguanides similar in molecular structure to chlorhexidine. They have also been tested clinically: In one study Alexidine® was found to have similar plaque inhibitory effects as chlorhexidine gluconate,[26] (Fig. 6). In another study this was also true when Vantocil was compared to chlorhexidine.[30,34] These stud-

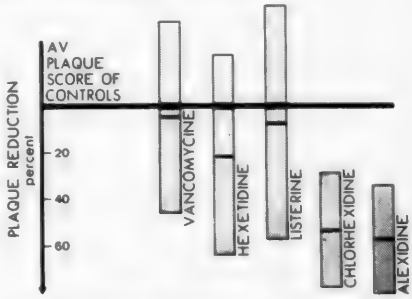


FIG. 6. Average reduction of interproximal plaque formation by various rinses containing antimicrobials. Dotted columns represent ± average stand. deviation. (Helv. Odont. Acta 17, 89, 1973)

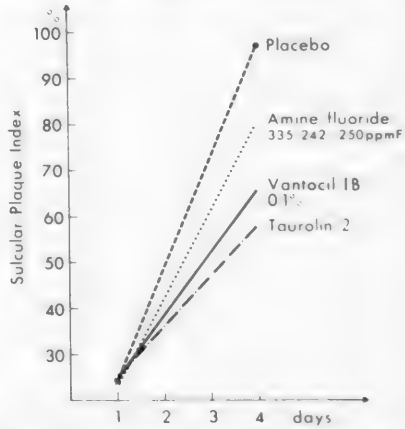


FIG. 7. Reduction of plaque formed during three days. Average Sulcular Plaque Index in 16 young adults rinsing with Taurolin, Vantocil and amine fluorides. (Helv. Odont. Acta 19, 57, 1975).

* Hawe Neos Dental, CH-6925 Gentilino, Switzerland.

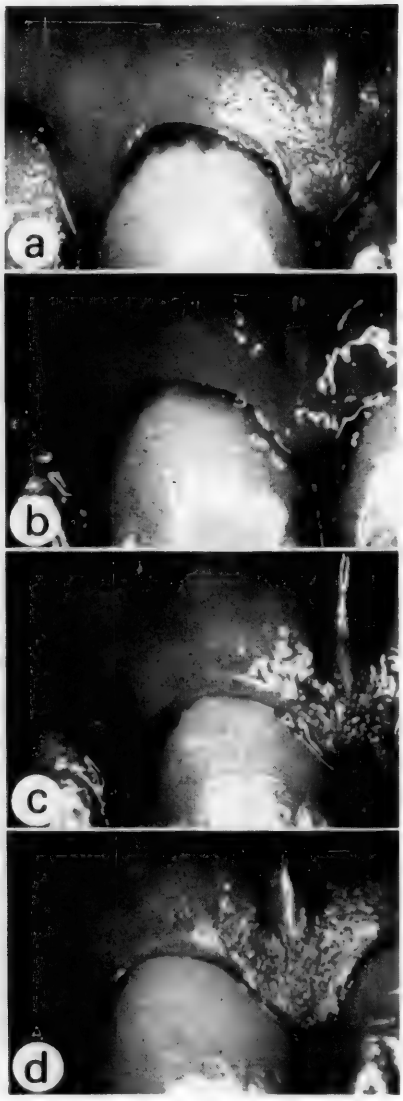


FIG. 8. Three-day-old plaque formed on upper right incisor in an individual selected at random, among the participants of study represented in Figure 7. Effects of different rinses. Sulcular Plaque Indices A. Placebo 98%, B. Vantocil 65%, C. Taurolin 40%, D. amine fluorides 30%.

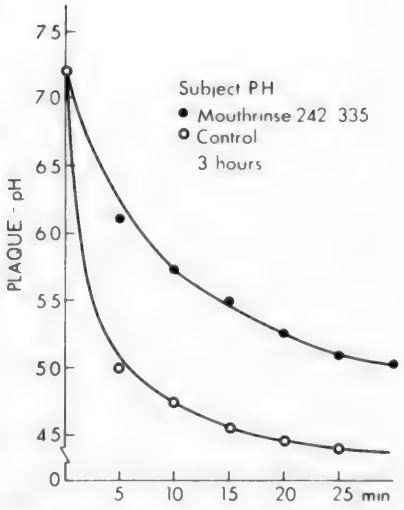


FIG. 9. Antiglycolytic action of aminefluoride on dental plaque. *In vitro* decrease in pH after adding 10% glucose to plaque collected before and three hours after a rinse with cetylamine/oleylamine hydrofluorides (242/335). (Helv. Odont. Acta, Supplementum VIII 18, 63, 1974)

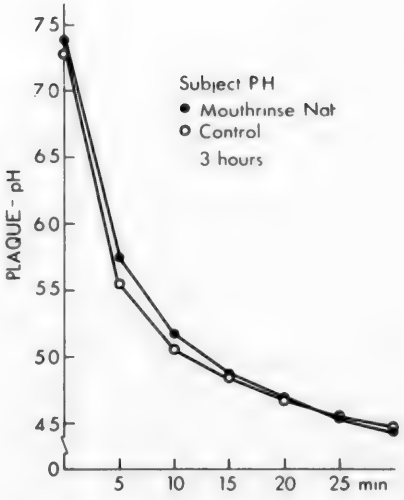


FIG. 10. *In vitro* decrease in pH after adding 10% glucose to plaque collected before and three hours after a rinse with sodium fluoride. Lack of antiglycolytic action of NaF. (Helv. Odont. Acta Supplement VIII 18, 63, 1974)

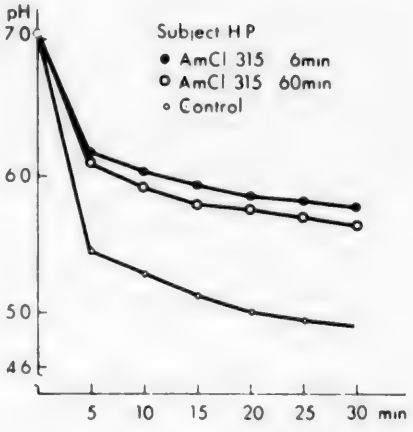


FIG. 11. *In vitro* decrease in pH after adding 10% glucose to plaque collected before and six minutes and 60 minutes respectively after a rinse with cetylamine hydrochloride. (Helv. Odont. Acta 19, 13, 1975)

ies suggest that the bis- or polybiguanide groups are essential for oral retention. Plüss[34] using planimetry found no significant differences in plaque reduction between Vantocil and Hibitane, at the end of a one week rinsing period, but interestingly enough, staining of the teeth was more pronounced for Vantocil (3.2 versus 1.0, $P_t < .001$). Brady *et al.*[9] showed a 55% reduction in plaque wet weight after five days of a daily one minute rinse with 0.035% Alexidine in 18% alcohol.

There was a reduction in bacterial concentration in preformed but not in newly formed plaque.

In another three day rinsing study[30] with three antimicrobials, including Vantocil®, using a latin square design, the average Sulcular Plaque Indices[30] revealed the following percentage plaque reductions (Fig. 7): for cetylamine-oleylamine·HF: 22, for Vantocil: 40 and for Taurolin®. A photograph of plaque inhibition in an individual after rinsing for three days is shown in Figure 8. (In this individual amine fluoride showed a more pronounced interference with plaque formation than Taurolin®. It should be noted that this was an exception and did not reflect the average effect of treatments. This individual case is presented to illustrate the plaque scoring system used. The plaque inhibitory effects of amine fluorides are probably due to (1) their depressive action on energy production in plaque antiglycolysis), (2) their plaquophilia and (3) their rendering the enamel surface plaquophobic.

Antiglycolytic Effects and Plaqueophilia of Amine Fluorides

The powerful inhibitory properties of glycolysis by amine fluorides[41] and amine chlorides[10] are represented in Figures 9–12. In this study, after allowing plaque to accumulate for 36 hours, subjects first rinsed with water. Plaque samples were then collected. Subjects then rinsed with either amine fluoride 297, or with a combination of cetylamine.HF/oleylamine.HF or with sodium fluoride. Plaque was again collected after 0.1, one, three, six and ten hours. The samples subsequently were exposed *in vitro* to ten per cent sucrose and pH changes were recorded for 30 minutes. Depression of glycolytic acid formation was still detectable six hours

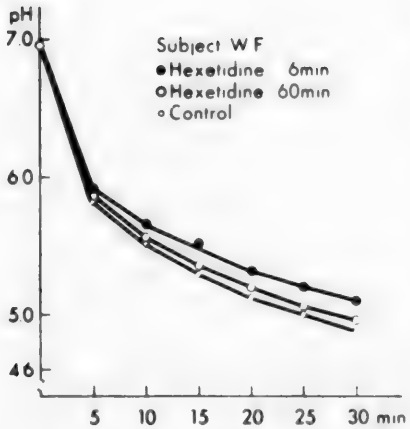


FIG. 12. *In vitro* decrease in pH after adding 10% glucose to plaque collected six minutes and 60 minutes respectively before and after a rinse with hexetidine. Lack of antiglycolytic action of hexetidine. (Helv. Odont. Acta 19, 13, 1975)

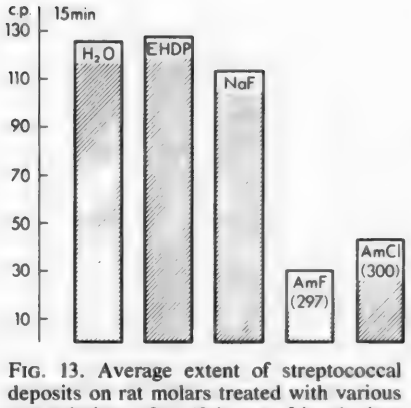


FIG. 13. Average extent of streptococcal deposits on rat molars treated with various test solutions after 48 hours of incubation. Inhibition of deposit formation by amine fluoride 297 and amine chloride 300. No effect of sodium fluoride and EHDP. (Helv. Odont. Acta 18, 45, 1974)

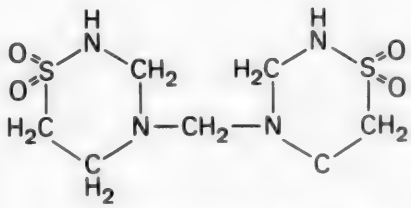


FIG. 14. Structural formula of Taurolin®.

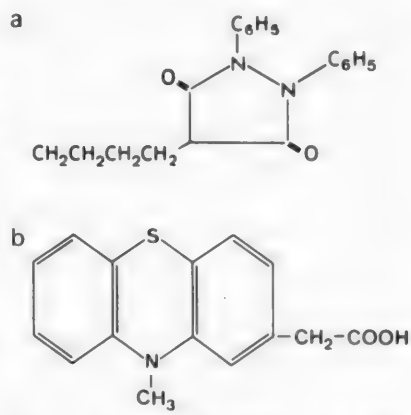


FIG. 15. Structural formulae of a) butazolidin dipyrin (Irapyrin®) and b) metiacinic acid (Soripal®).

after rinsing with amine fluorides[41] (Fig. 9). In contrast, the anti-enzymatic effect of sodium fluoride had vanished after one hour (Fig. 10). Breitenmoser[10] compared the antiglycolytic action of amine chlorides with a classical disinfectant hexetidine. The antiglycolytic effect of amine chlorides was similar to inhibition of acid formation in plaque by amine fluorides (Fig. 11). Hexetidine did not interfere with the drop in pH (Fig. 12) suggesting a lack of plaquophilia and retention. In a previous plaque inhibition test[26] hexetidine was also found without antiplaque action which is in agreement with findings by Bergenholz and Hänström.[7]

Plaquophobic Effect of Amine Fluorides on Plaque Free Enamel

In vitro treatment of rat molars with the hydrofluorides or hydrochlorides of bis - (hydroxyethyl) - aminopropyl - N-hydroxy-ethyl-octadeyl amine (compound 297) provided pronounced bacteriophobia to the smooth enamel surfaces[4] (Fig. 13) when compared with the treatment by inorganic sodium fluoride and a water control.

A New Plaque Inhibitor, Taurolin®

As already mentioned, Taurolin® was found to be superior to a polybiguanide in inhibiting plaque formation in a three day clinical test.[30] However, Taurolin® was used ten times more concentrated (2%), the rinsing solution being organoleptically acceptable.

Taurolin is a derivate of a perhydro-1, 2, 4-thiodiazin-dioxide methane (Fig. 14). It is synthesized by condensing the sulfur-containing amino acid taurine with formaldehyde. Taurolin has greater stability in aqueous solution than other formaldehyde releasing chemicals. Its in vitro antibacterial activity is not very pronounced. The oral LD50 has been reported to be 2.0–2.5 g/kg in rats.

In the future Taurolin should be tested primarily for its effect on gingivitis because it inactivates endotoxins (from *E. coli*) and is less irritating to tissue than formaldehyde. Its taste is not objectionable at a relatively high concentration.

ANTIINFLAMMATORY MEDIATORS OF GINGIVAL HEALTH

Chronic inflammation has been incriminated as responsible for destructive lysis of periodontal connective tissue and bone. The development, in recent years, of a myriad of nonsteroid antiinflammatory agents, recommended for depressing traumatic, infectious and rheumatic inflammation, has also stimulated clinical dental pharmacology. In this area we have been involved in various studies which will be briefly summarized.

Effect of Systemic Antiphlogistics

The effect of butazolidin-dipyrin (Irgapyrin®) and of metiacinic acid (Soripal®) respectively on gingival inflammation was investigated by Müller.[35] The structural formulae of the compounds are represented in Figure 15. One half gram of the drugs were administered three times daily for three days to six subjects with clinically distinct gingivitis, the average SBI-score being approximately two. The rate of flow of sulcus fluid collected prior to and after systemic antiinflammatory treatments was not significantly different from placebo treatments (Fig. 16).

Effect of Topical Antiphlogistics

Topical application of antiinflammatory agents did not result in consistent reduction of gingival inflammation. In a *first study*[3] 12 subjects with gingivitis applied the following three test gels successively for four days: 0.1% acetyl salicylic acid, 0.1% indomethacin (Fig. 17) and placebo. Individual trays filled with gel and covering the maxillary teeth and gingivae were applied for 15 minutes daily, over a period of one week. Every second day the sulcus fluid flow rate was measured at six different gingival sites. Another four subjects applied

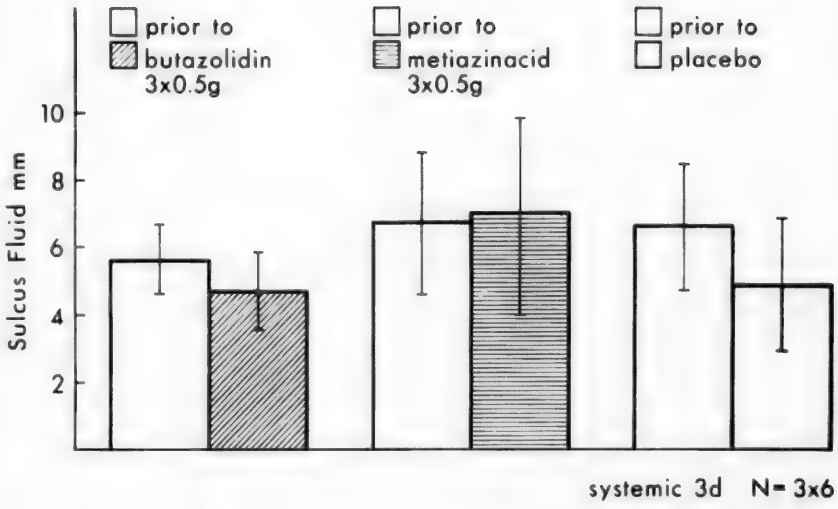


FIG. 16. Effect on gingival inflammation (sums of sulcus fluid collected) of systemic butazolidin and metiacinic acid administered for three days. Lack of significant differences. (Müller, L.: Medical Thesis, University of Zürich, 1975)

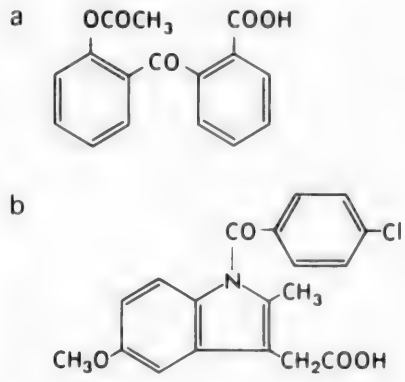


FIG. 17. Structural formulae of a) acetyl salicylic acid (Aspirin®) and b) indometacin.

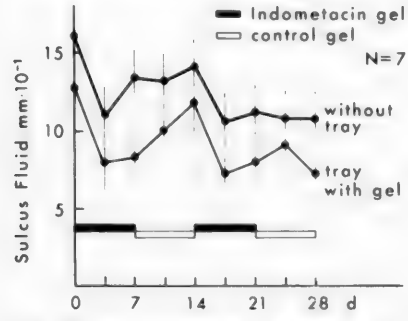


FIG. 18. Average sulcus fluid flow rate in 7 subjects applying topically indometacin gel (days 0–7 and 14–21) and placebo gel (days 7–14 and 21–28) on the test side with a tray. The contralateral side served as control (without tray). Significantly higher inhibition of sulcus fluid flow rate with indometacin gel when compared with control gel. (Blum-Diriwächter, U.: Medical Thesis, University of Zürich, 1975)

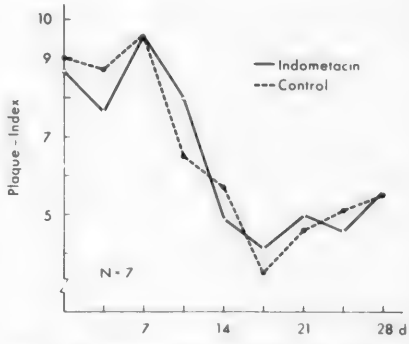


FIG. 19. Significant decrease of average Plaque Indices (sums) on the test- and control side during the clinical study represented in Figure 18. (Blum-Diriwächter, U.: Medical Thesis, University of Zürich, 1975)

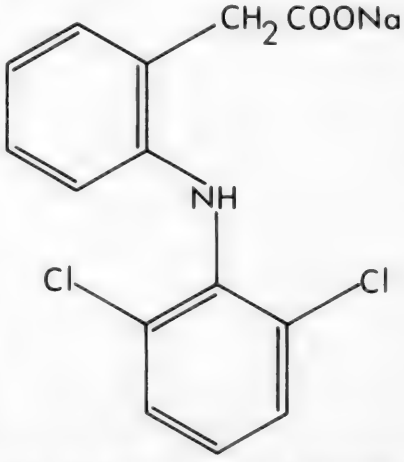


FIG. 20. Structural formula of diclofenac sodium (Voltaren®).

the test gels successively, each for four weeks. Crevicular fluid measurements were made twice a week. There was no significant difference between acetyl salicylic acid and placebo in the four-day-trial; but in the four-week-test a non-significant tendency to a reduction of the rate of sulcus fluid flow was observed for Aspirin®. Indomethacin (Fig. 19b) did not reduce gingival inflammation. This result is in contrast to the observations made in a second study by Blum-Diriwächter.[37] Using a half-mouth design in seven subjects with clinically distinct gingivitis (SBI ~ 2.0), she topically applied: 1) a gel containing 0.1% indomethacin and 2) a placebo gel, both for ten minutes daily with weekly alternating treatment periods. The tray filled with gel covered the gingivae of one-half of the maxillary or mandibular anterior teeth from the second premolar to the central incisor. The gingivae of the corresponding contralateral teeth *were not exposed* to the gel. Sulcus exudate was measured over a period of four weeks at average intervals of three and one half days. The results, summarized in Figure 18, revealed a significantly greater inhibition of exudate flow with the indomethacin gel when compared with the placebo gel. In this half month design some leakage from the trays occurred since similar observations were made on the sides where no sets were applied.

The effect on dental plaque, during the study of both gels, is of additional interest. As is shown in Figure 19, the plaque index decreased by approximately 50% during the initial two weeks although the subjects had been instructed not to change oral hygiene habits. Plaque was not removed professionally during the test period.

In a third study, a group of eight subjects with pronounced gingivitis was treated topically with diclofenac sodium (Voltaren®),[11] whose structural formulae is given in Figure 20. The antirheumatic effect of diclofenac sodium was described as being similar to indomethacin.[3,20] The gingivae were exposed to diclofenac sodium gel or a placebo-gel for ten minutes daily using an individual plastic tray for the maxillary anterior teeth during the first week. There was no application during the second week. During the third week, the Voltaren-treated subjects changed to the placebo-gel, whereas the placebo treated subjects started using diclofenac sodium. Sulcus fluid was measured at average inter-

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Brief Summary
Composition: Each teaspoonful (5 ml.) contains 1.0 milligram fluoride ion (from 2.2 mg. sodium fluoride) in an M/10 phosphate solution at pH 4 in lime, orange or cherry flavor. **Contraindications:** Do not swallow in areas where the drinking water contains more than 0.7 ppm F. **Precaution:** Recommended systemic dosage should not be exceeded, as prolonged overdosage may result in dental fluorosis. **Dosage and Administration:** Children age 3 and over—preferably at bedtime after brushing teeth. In areas where drinking water is devoid of fluoride (0-0.3 ppm), one teaspoonful (5 ml.) to be rinsed around and between the teeth for one minute before swallowing. When drinking water contains 0.4 to 0.7 ppm F, reduce dose to one-half a teaspoonful. When drinking water contains more than 0.7 ppm F, one teaspoonful (5 ml.) to be rinsed around and between teeth for one minute, *then expectorate.* Do not eat, drink or rinse mouth for at least 15 minutes afterward. **How Supplied:** 250 ml. and 500 ml. plastic bottles. Choice of orange, cherry and lime flavors.

CAUTION: Federal (U.S.A.) law prohibits dispensing without prescription.
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[1]Aasenden, et al., Effects of Daily Rinsing and Ingestion of Fluoride Solutions Upon Dental Caries and Enamel Fluoride, *Arch. Oral Biol. 17:* 1705-1714, 1972. [2]Frankl, S.N., et al., The Topical Anticariogenic Effect of Daily Rinsing with an Acidulated Fluoride Phosphate Solution, *JADA 85:* 1972. [3]Finn, S.B., et al., The Clinical Cariostatic Effectiveness of Two Concentrations of Acidulated Phosphate-Fluoride Mouthwash, *JADA 90:* 1975.

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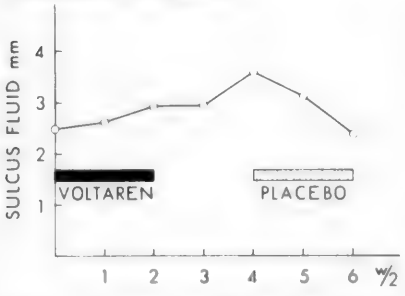

FIG. 21. Average sulcus fluid flow rate in five subjects during six half weeks (w/s). Start with topical application of Voltaren®. After interval application of placebo gel. (Burger, St.: Medical Thesis, University of Zürich, 1976)

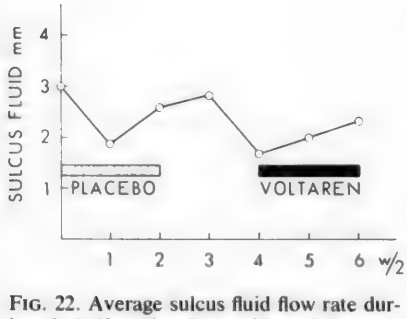

FIG. 22. Average sulcus fluid flow rate during six half weeks. Start with topical application of placebo. After interval treatment with Voltaren gel.

vals of three and one half days over the three-week-period. The intensity of gingival inflammation was not changed by either gels (Figs. 21 and 22). In order to eliminate doubts concerning the sensitivity and validity of sulcus fluid measurements, three additional subjects were exposed to daily topical applications of decamethasone (Kenalog® in Orabase®).[21] After three days, and six days, sulcus fluid flow was reduced by almost 50% indicating the response of the inflamed gingivae to a topical steroid. The reduction of gingival inflammation was also evident by simple clinical inspection. Such an observation has never been made with topically applied non-steroid antirheumatic agents.

From the studies with antiinflammatory non-steroids, it is not known whether permeation of the oral and junctional epithelium has been hindered by inadequate water and liposolubilities of the agents. It is possible that the antiphlogistics did not reach the subepithelial target. Nevertheless, systemic butazolidin, whose anti-edematous and anti-inflammatory actions are well documented, was without effect on gingival inflammation. Apparently, the gingival inflammation model is not suitable for the screening of antirheumatics in human subjects. However, it is too early to condemn the clinical usefulness of antiphlogistics which, under various experimental conditions, have been shown to interfere significantly with humoral and cellular immune responses, activated complement, prostaglandins, histamines, etc. Nevertheless, at present, among chemcal mediators topical antiplaque agents, combined with mechanical plaque removal are more successful and reliable than antiinflammatory compounds in contributing to gingival health.

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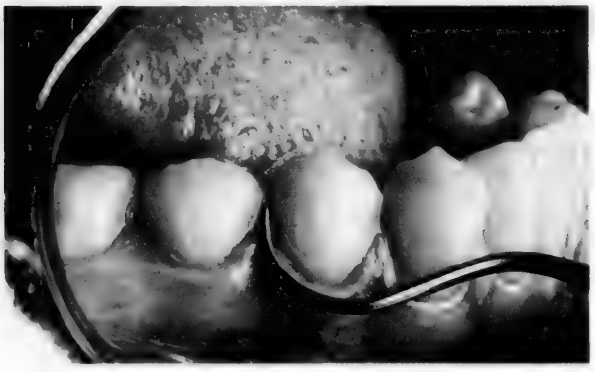

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Patient Motivation with the Papillary Bleeding Index

U. P. Saxer, B. Turconi and Ch. Elsässer

The increasing amount of literature dealing with various oral hygiene and motivational procedures has demonstrated that to date there seems to exist neither a superior technique of plaque control nor a generally accepted method for the motivation of dental patients. However, a number of studies in various geographical areas have shown marked improvements in oral health. Recently a 50 per cent reduction of the DMFS and a 30 per cent decrease in gingival inflammation was reported in a cross-sectional, 10 year investigation of a segment of the Swiss population not exposed to fluoridated water.[9]

Marginal periodontitis and alveolar bone loss begin interproximally.[6] Therefore, future efforts in disease prevention should be directed towards this vulnerable area. The most difficult aspect of any oral hygiene program is the removal of interdental plaque. The literature abounds with reports suggesting and supporting the use of dental floss and other devices to remove plaque between teeth.[5,11] Regardless of the methods used, they are all time consuming, tedious to the patient, and require good motivation.

The relative ineffectiveness of conventional motivational methods, such as the use of plaque disclosing agents, has been discussed recently.[11] Successful prevention can only result from the coordinated efforts of the patient, the dentist and the insurance administrator. A language understandable to all members of this Dental Troika[11] will be a necessity in the future. Gingival bleeding is an unequivocal symptom of disease understandable by all three parties.

The following two studies were performed to determine if papillary bleeding, when applied as a means of patient motivation, was effective in a preventive dentistry program.

MATERIALS AND METHODS

Study A

Twenty years of experience with the "Modified PMA-Index", now termed "Sulcus Bleeding Index",[10] in which sulcus bleeding upon gentle probing is considered the most significant symptom of gingival inflammation, has resulted recently in a simplified scoring system: the "Papillary Bleeding Index" (PBI, Mühlemann 1976). The definitions of the PB-scores are formulated in Table 1. The Papillary Bleeding Index Form used for recording the scores has been published elsewhere[11] and was used in study A for (1) assessing the severity of gingivitis, and (2) patient motivation.

Table 1.

Score	Bleeding on gentle probing
0	No bleeding
1	Only one bleeding-point appearing
2	Several isolated bleeding-points or a small blood area appearing
3	Interdental triangle filled with blood soon after probing
4	Profuse bleeding when probing, blood spreading towards the marginal gingiva

The patients had to participate actively with a hand mirror when papillary areas were probed, visualizing from session to session the improvement in gingival health. The gradual decrease in the number of bleeding papillae and in the intensity of the bleeding recorded on the PBI Forms convinced patients of the importance of their active participation, and of the value of their health effort.

The patients were neither instructed nor motivated to remove plaque. Disclosing of plaque for the evaluation of oral hygiene was not used. Instead, their primary goal was attainment of non bleeding papillae. This symptom of disease was observed by the patients themselves during daily homecare. Patients knew that bleeding was caused by microbial agglomerates and that regular and conscientious cleansing of tooth surfaces would result in gingival health, in other words in non-bleeding papillae.

The usefulness and practicability of this kind of motivation was evaluated in 140 patients who reported for a prophylaxis at the Zurich Dental Hygiene School. The patients were treated by 20 senior dental hygiene students supervised by three dental hygiene instructors. The students had been instructed in the use of the PBI. They scored papillary bleeding in the upper right and lower left jaw lingually and in the upper left and lower right jaw buccally. These scores were totaled and their sum recorded for each session. The scoring sessions were repeated at weekly intervals and the results discussed with the patients. On the Papillary Bleeding Index Form the patients could follow the quantitative changes in their gingival health status. They were informed in detail how to reduce and eliminate bleeding in the diseased areas by appropriate oral hygiene

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procedures. When gingival health improvement occurred from one session to the next, the students encouraged and complemented the patients.

At the beginning and frequently at subsequent sessions, marginal iatrogenic irritants were removed, oral restorations were polished and teeth were scaled.

Study B

Study B was designed to observe the motivational effect of the PBI when used in a public health program. A community whose 209 children had received no preventive information at school was chosen. Health instruction was initiated by dental hygienists in 9 different classes (Table 2). The children were told that bleeding from the gums was a disease and that bleeding would lead to the destruction of teeth and alveolar bone. This point was greatly emphasized. In addition to this motivation, the children received toothbrushing instructions from two dental hygienists daily for 14 days. A modified Fones technique was taught as the only plaque removing aid. Subsequently, the teachers agreed to supervise toothbrushing once every second week. The teachers were instructed in their supervisory role by a dentist. They were told to stress repeatedly that bleeding gums is equivalent to oral disease. They had no further assistance from dental-oriented personnel.

Papillary inflammation in each child was scored and recorded (1) before the first prophylaxis, (2) after the intensive dental hygienist instruction period, and (3) six months later. For each child the scores were added and averages were calculated for the different classes. At the second and third examination 11 children were not available because of sickness. Another 29 were absent because they had moved to another community. The number and age of the children comprising 9 different classes and examined three consecutive times are shown in Table 2.

RESULTS

Study A

For evaluation purposes the patients were classified into three groups according to the number of treatments received. Patients of *group 1* were treated three times; these were mainly recall patients. *Group 2* received treatment four times and *group 3* had five or more sessions. Treatment times were variable since they were dependent on the amount of calculus and stains to be removed and on the number of iatrogenic irritations requiring corrections.

A total elimination of papillary bleeding was observed in the 20 recall patients of group 1. In groups 2 and 3 the papillary bleeding score sums were reduced by 82 per cent. The mean reduction in all three groups was after two to 7 weeks 86 per cent. The method proved to be a reliable measure of the disappearance of gingival disease.

Study B

The results are presented in Table 2. At the beginning of the study an average PBI-sum of 15.5 was recorded for all 9 classes. After the 14 day motivation and instruction period the average PBI-sum had decreased to 6.1. It rose again slightly between the second and third examination to 8.6. The overall reduction of disease after 6 months was 45 per cent for all classes.

The PBI did not show any significant differences between groups in 7 classes during the period in which the teachers instructed the children in toothbrushing. When comparing the third with the second examination, the PBI rose slightly more than 1.0 in three classes. In three other classes, it increased less than *1.0*, while in one it decreased. In two of the classes it increased more than 5.0 to reach the level recorded at the onset of the study (Table 2).

DISCUSSION

The findings in study A are in agreement with the report of Carter *et al.*[1] who found a 75 per cent reduction in gingival papillary bleeding in a similar intensive oral hygiene program. In their study, unwaxed dental floss was used daily for one week. Although our present results would not permit us to recommend patient motivation with the papillary bleeding index as a method superior to conventional plaque oriented motivation, our clinical experience suggests that the bleeding symptom seems to be more dramatic to the patient than the demonstration of uncleanliness.

The intensive motivational and instructional procedure in study B by dental hygienists and later by teachers resulted in a marked improvement in *gingival* health. The term "improvement of *oral* health" would probably be more appropriate since the removal of

Table 2. Average Papillary Bleeding Index Sums of 169 Children in 9 School Classes at the Onset (I), after Two Weeks of Daily Supervised Toothbrushing and Motivation by Dental Hygienists (II) and Six Months After (III).

Class	Age	Number of children	Examination		
			I	II	III
KG	5– 6	13	9.00 ± 11.0	3.8 ± 5.6*	4.2 ± 4.3
1	6– 8	23	11.19 ± 9.6	6.3 ± 5.0*	12.9 ± 12.8**
2	7– 9	19	12.8 ± 11.2	4.5 ± 4.1**	12.8 ± 12.2**
3	8–10	23	15.7 ± 8.1	5.9 ± 3.6†	7.8 ± 4.2
4	9–11	20	14.3 ± 8.1	6.1 ± 4.8†	6.8 ± 5.9
5	10–12	10	19.5 ± 13.9	6.0 ± 4.1**	7.6 ± 3.5
6	11–13	23	17.4 ± 13.7	7.1 ± 6.5†	7.9 ± 9.0
7	12–14	24	19.2 ± 9.1	6.8 ± 6.1†	6.3 ± 6.5
8	13–14	14	22.0 ± 13.3	7.5 ± 5.6†	9.5 ± 7.5
Total			15.5 ± 11.1	6.2 ± 5.1†	8.6 ± 8.6†

* $p < 0.05$.
** $p < 0.01$.
† $p < 0.005$.

interdental plaque and subsequent elimination of papillary bleeding can be certainly associated with a depression of caries activity.

In some classes no significant increase in the Papillary Bleeding Index was evident during the "teacher period". These teachers were found to be very knowledgeable and effective in teaching oral hygiene measures to the children.

In classes 1 and 2 the PBI increased to the level of prestudy scores. The two teachers, we found, were little motivated (classes 1 and 2) and subsequently showed minimal interest in the oral health program.

In comparing the results of study B with findings reported by Lindhe and Koch,[8] one notes that the school children in study B showed a 50 per cent improvement of their gingival health 6 months after cessation of professional instruction. Lindhe and Koch[8] observed insufficient maintenance of gingival health after cessation of supervised oral hygiene.

Lightner *et al.*[7] studied the oral hygiene standard of 470 military personnel over a four years period. The military personnel received one to four prophylaxes per year with different degrees of motivation and instruction. Repeated preventive treatment and instruction in toothbrushing resulted in a significant decrease in gingival inflammation. Frequent preventive treatments and toothbrushing instruction were effective over a longer time period in reducing formation of plaque and hard deposits and in retarding alveolar bone loss. The average gingival score decreased from 1.8 to only 1.3. Despite this statistical significance, the clinical relevance of this decrease is questionable. In addition, the study was not designed to measure motivational effects but to demonstrate the effectiveness of oral hygiene.

Also Suomi[13] failed to show a significant decrease in gingival inflammation in a three year oral hygiene program using conventional plaque disclosing motivation. This is in agreement with the difficulty we found (unpublished data) in motivating patients by demonstrating to them the amount of plaque as proposed by Garnick.[4]

The findings in study B are not comparable to those reported by Clark *et al.*,[2] as the diagnostic criteria for the evaluation of progress were fundamentally different. They are, however, in agreement with Eduards'[3] observations of 58 male participants in a health prevention program utilizing a bleeding and plaque index. A 50 per cent reduction of gingival bleeding was reported; the decrement of the plaque index being almost 70 per cent.

SUMMARY

Patient motivation and education by means of the Papillary Bleeding Index was effective in a preventive dentistry program. Studies A and B suggested that oral health motivation does not necessarily depend on plaque disclosing procedures. Demonstration of a symptom of disease, gingival bleeding, being easily comprehendable by the patient, should merit more attention as a diagnostic aid and stimulus toward better oral hygiene.

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Erratum

In the May-June issue of Journal of Preventive Dentistry, the article "Arch Length" by Arnold J. Malerman D.D.S. appeared with major typesetting errors. The September-October issue will carry the article in its correct form.

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PROFESSIONALLY APPLIED TOPICAL FLUORIDES

Sodium Fluoride

Sodium fluoride has been used since the 1940's when it was first introduced by Knutson and co-workers.[19,20,36–38] Knutson's procedure includes a pumice prophylaxis followed by the application of a 2 per cent sodium fluoride solution at pH 7 for 4 minutes. This initial topical application is then followed by three additional applications without prophylaxis at weekly intervals. The benefits were reduced by about one-half when the initial prophylaxis was eliminated and additional prophylaxis at subsequent applications did not enhance the cariostatic effects. The four applications of sodium fluoride were recommended at the ages of 3, 7, 10, and 13 years to receive optimal benefits. One of the major disadvantages of the Knutson technique is that patients must return to the dental office four times within a short period of time. This does not fit well in a private dental office routine. However, in a public health program, by the use of multiple chairs and auxiliary personnel, the cost-effectiveness and cost benefits of such a program are more acceptable.[61] The reduction in dental caries in children in non-fluoridated communities is in the 30 per cent range.[28] It is of little benefit to the teeth of adults and to subjects in fluoridated communities.[69]

Stannous Fluoride (SnF_2)

When a freshly prepared 8 or 10 per cent solution of stannous fluoride is recommended, the teeth are kept moist continuously for 4 minutes with reapplication of the solution every 15 or 30 seconds. Semiannual applications of stannous fluoride give better caries inhibition than annual treatments. There is a large variance on the degree of caries inhibition obtained with stannous fluoride solutions ranging from over 80 per cent[33] to negative reductions.[75] However, the majority of the studies have confirmed its effectiveness and the caries inhibition of semiannual topical applications of 8 to 10 per cent solutions of SnF_2 may be expected to be in the 40 to 50 per cent range.[6,29,30,32,44,45,61,69] A greater dental caries reduction has been reported using a multiple regimen of zirconium silicate prophylaxis paste containing stannous fluoride (professionally or self-applied) followed by a 10 per cent SnF_2 solution and the home use of a stannous fluoride-calcium pyrophosphate dentifrice.[22,47] In the U.S. Navy, a treatment regime consisting of approximately 10 minutes of supervised brushing with a stannous fluoride lava pumice prophylaxis paste followed by a 15–30 second topical application of a 10 per cent stannous fluoride solution and daily use of a

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stannous fluoride dentifrice has been found to reduce the development of new cavities by 52 per cent.[53,54]

Notwithstanding the caries inhibition of 8 to 10 per cent stannous fluoride solution it is used even less, particularly in children, because of its astringent and disagreeable taste. Other disadvantages include its instability in aqueous solutions, the possible pigmentation around carious lesions or hypo-calcified areas of the teeth,[34] and possible gingival blanching and irritation.[50]

Acidulated Phosphate Fluoride (APF) Solution

Presently, APF is probably the most widely used topical fluoride agent. Most formulas contain 1.23 per cent sodium fluoride and orthophosphoric acid (0.1M) at a pH of about 3.5. The low pH enhances greater fluoride uptake while the enamel dissolution is somewhat suppressed by the presence of phosphate ions.

The conventionally recommended procedures for topical application of APF and stannous fluoride solutions are similar, that is, they should be preceded by a thorough prophylaxis, interproximal flossing and drying with compressed air. Half of the mouth or the full mouth may be treated at one time. The solution is applied to the dried surfaces of the teeth with a cotton swab, keeping the teeth moist continuously for a period of 4 minutes. Although a longer exposure time and more frequent reapplications of a fluoride solution may produce a slightly greater fluoride uptake, the greatest fluoride uptake occurs during the first four minutes. After treatment, the patient may expectorate but is instructed not to eat, drink or rinse for at least 30 minutes to enhance further fluoride penetration and retention. Generally speaking, applications are given twice a year coinciding with the 6 monthly recall schedule. In highly susceptible patients the application should be repeated three or four times a year. The caries reduction of APF solutions when professionally applied, semiannually to subjects in non-fluoridated communities averages around 40 to 50 per cent.[4,12,25,27,35,74,75]

APF Gel Versus Solution

Most APF preparations are now available in the gel form by the incorporation of hydroxymethylcellulose, sodium alginate or other gelling agents. The fluoride gel has advantages of being more easily applied with a cotton swab, better flavored, pleasantly colored and easier for the therapist to visualize the location of applied fluoride. Although most preparations available today have improved flavors, a few are still poorly accepted by children. Dentists and hygienists should personally try the flavors to avoid imposing a poorly tasting agent on their patients.[71]

Gels vary in viscosity which may affect their ability to penetrate into the interproximal areas of teeth. The use of dental floss to carry the gel interproximally partly overcomes this disadvantage.[71] The fluoride uptake of enamel from a gel preparation is comparable to the uptake from a solution with the same chemical active ingredient at the same pH and concentration.[68] Gels are also more easily used when the topical fluoride is applied *via* a mouth tray. The selection of a solution or gel should be based on cost, patient acceptance, personal preference and whether the fluoride is applied with cotton swab or a mouth tray.

It should be indicated that although the original APF solutions were formulated at pH 3.0 to 3.5, nearly all commercially available gels now have a pH of 4.5 to 5.5. At pH 3.0 to 3.5 the shelf life of a methylcellulose-based gel is greatly reduced due to loss of viscosity. The higher pH also improves palatability and patient acceptance. Theoretically, the fluoride uptake should also be reduced by the elevation of the pH.

TOPICAL FLUORIDE TRAYS

A large number of tray systems are available for the delivery of topical fluoride solutions and gels.[64,71] The commonly used types include wax trays (Hoyt Lab., Lorvic Corp.), reusable vinyl trays (Pacemaker Corp., Janar Corp., Pascal Co., Inc., and Unitek Corp.), disposable polystyrene trays to be used without filter paper insert (Pacemaker Corp.) an Air Cushion Fluoridator with a filter paper insert (3M Co.) and the Flura-tray topical fluoride system with a foam liner insert (Kerr Co.).

The wax trays are generally less satisfactory because they take time and care to adapt to each subject's dental arch and are poor retainers for fluoride gels. The reusable vinyl trays come in a limited number of sizes. They are probably more

satisfactory if they are used in conjunction with filter paper inserts.[71]

The Air Cushion Fluoridator appears to be a satisfactory system. The saliva suction device reduces salivary dilution and uncomfortable drooling. When the air cushion rubber tray is removed, the filter paper usually remains on the teeth and needs to be separately retrieved. This shows that the gel is in direct contact with the enamel surface. Usually it takes 8 to 10 minutes to complete both upper and lower arches. The main disadvantage is that these trays can not be autoclaved and need to be washed with hot soapy water and stored in cold chemical disinfectants.

The Flura-tray system reduces the time to 4 minutes by the use of a double tray and a foam liner which swells when fluoride gel is placed on it. However, the polyvinyl trays used are of a stock size design and are uncomfortable unless the trays are cut down in the posterior border. Also, a great deal of gel is required to saturate the foam liner to produce effective contact of the fluoride with the teeth.

The disposable polystyrene tray appears to be a promising new development. It is well contoured, disposable and comes in a variety of sizes. It is soft, pliable, comfortable and readily accepted by patients. It provides good retention for a fluoride gel.

Individual custom fitted mouthguards made from a thermoplastic or vacuum processed vinyl may be used,[16] however, they are expensive and are not as practical in the dental office as the other methods.

FLUORIDE PROPHYLAXIS PASTES

The dentist is sometimes confused by the large number of fluoride containing prophylaxis pastes which are commercially available. They fall basically into the two categories, stannous fluoride or APF containing pastes. The abrasive used must be compatible with the type of fluoride in the paste.

Stannous fluoride has been combined with either lava pumice or zirconium silicate as polishing agents. More recently, a combination of stannous fluoride, monobasic sodium phosphate (NaH_2PO_4) and zirconium silicate has been found to be effective in polishing and cleaning teeth.[52]

Prophylaxis pastes containing APF may use silicone dioxide, insoluble metaphosphate or zirconium silicate as abrasives and are generally more pleasantly tasting than SnF_2 counterparts.[71] Usually a selection of the abrasivity from fine, medium, coarse to extra corase is available depending on the needs of particular mouths. It is important to emphasize that prophylaxis of teeth should not be done overzealously, as this may remove 3 to 6 μm of the fluoride rich surface layer of enamel.[66,67] It should be emphasized that the use of fluoride containing paste does not replace a topical fluoride treatment using a concentrated fluoride solution or gel. Many adult patients who have little or no caries but who receive regular scaling and prophylaxis would benefit if the fluoride containing paste is allowed to remain in the mouth for several minutes before rinsing with water.[67,71]

The mixture of fluoride solution and pumice for prophylaxis is contraindicated as pumice will inactivate the fluoride by direct interaction as well as raising the pH of the fluoride solution, and thereby reducing the fluoride uptake at the enamel surface.

IS A PROFESSIONAL PROPHYLAXIS AN ESSENTIAL PREREQUISITE TO A TOPICAL FLUORIDE TREATMENT?

In subjects with plaque accumulation and severe staining of the teeth, a professional prophylaxis is essential to render the teeth clean and to enhance fluoride uptake. However, in some children who have minimal plaque or stains, a supervised flossing and tooth brushing with a fluoride containing cleaning paste or dentifrice immediately prior to the topical application may be substituted for a professionally administered prophylaxis.[10,62,71]

The effects of the salivary pellicle on the uptake of topically applied fluoride was studied recently by Tinanoff and co-workers. Although an *in vitro* study[63] showed that the artificial pellicle slightly reduced the fluoride diffusion into enamel blocks, an *in vivo* study showed no difference in enamel fluoride uptake three days after a topically applied fluoride between a group that brushed their teeth before fluoride treatment and a second group which received a pumice prophylaxis before the fluoride treatment.[62]

For children with minimal stains or plaque accumulation, the use of a self-applied fluoride containing paste in the dental office prior to a topical fluoride application will save professional time, reduce costs to the patient, produce good fluoride uptake by enamel and may be potentially as beneficial as a professionally applied prophylaxis.

SELF APPLICATIONS OF TOPICAL FLUORIDE AGENTS

Self-applied topical agents have generally been shown to be effective when their use is supervised and treatment is repeated frequently.[42] For example, Englander *et al.*[16] reported the use of a neutral sodium fluoride gel containing 0.6 per cent F ion and a similar APF gel (pH 4.5) on the teeth of 500 children for 21 months in Cheektowaga, New York (0.3 ppm F). The fluoride gel was applied to custom fitted mouth trays at each school day for two years. An average of 245 6 minute topical treatments (one per day) were administered to each child under the supervision of dental hygienists. Caries inhibitions of 75 per cent with the APF gel and 80 per cent with the neutral sodium fluoride gel were reported. The dental caries inhibition also appear to have been sustained for two years following the cessation of the daily fluoride gel applications; children who received the APF gel had 63 per cent fewer carious lesions than the controls while those using the NaF gel had 55 per cent fewer cavities.[15] These studies[15–17] helped to establish the safety of multiple intensive self applications of topical fluoride at home or at school since no undesirable side effects have been reported. No enamel fluorosis of anterior teeth or bicuspids are expected if the fluoride is used by school children after ages 6 to 7.

HOME FLUORIDE TREATMENT

For children or adults with severe or rampant caries with or without fluoridated water, a "therapeutic" course of multiple and intensive fluoride topical applications may be prescribed by the dentist. The daily home use of a fluoride gel (0.6% F) is indicated.[71] Many commercial APF gels are available including Resque-Squad Fluoride Home Treatment Kit (Unitek Corp.), the Home Treatment Kit (Pacemaker Corp., Karigel, and Lorvic Corp.) and Luride Gel-drops (Hoyt Co.).

A water-free flavored gel containing 0.4 per cent stannous fluoride sodium carboxymethyl-cellulose and glycerin is also available (Gel-Kam, First Texas Pharmaceutical, Inc.). The gel is diluted with equal parts of deionized water just prior to its use to release the stannous and fluoride ions. The gel appears to be stable and does not lose its effectiveness after aging for 15 months.[55] This gel preparation has been used widely in dental clinics of the United States Veterans' Administration Hospitals both in fluoridated and non-fluoridated communities.[57] It has been found effective in reducing dental caries in patients who are undergoing radiation therapy of the oral and nasopharyngeal areas and to prevent the development of root caries.[13] When this gel was applied conscientiously by orthodontic patients with a toothbrush following regular toothbrushing with a customary dentifrice at bedtime, the amount of demineralization of enamel around and under orthodontic bands was found to be reduced.[60] Further documentation of the relative clinical efficacy of stannous fluoride gel preparations compared to other agents appears highly desirable.

The use of the polystyrene trays in conjunction with one of the above preparations appears to best meet the requirements for home topical fluoride therapy. A prescription for 250 ml of APF gel (0.6% F ion) should last for about three months. This therapy may be commenced prior to and during the active phases of restorative dentistry. Once the severe caries have been controlled, this therapy may be continued with lower potency fluoride supplements such as fluoride mouthrinses or fluoride tablets. The home use of a fluoride prophylaxis paste and mouthrinse is contraindicated in pre-school children who may swallow a high percentage of a fluoride rinse which could lead to the possibility of enamel fluorosis.[49,71]

INFREQUENT SELF APPLICATIONS

The shortage and maldistribution of dental manpower along with the relatively high cost of the treatment are the major disadvantages of professionally administered topical fluorides as public health measures. In order to overcome these drawbacks, the use of self-application procedures

(brushing or mouthrinsing) for the delivery of topical fluorides has recently been investigated.[39]

Sodium Fluoride and APF

The use of a supervised toothbrushing procedure to administer a neutral 1 per cent NaF solution 9 times in a two-year period was evaluated as early as 1960 by Swedish investigators.[1] Their results revealed a 16 per cent reduction in DMF teeth compared to the control. In 1964 Berggren and Welander[2] also tested the effectiveness of sodium, zirconium and ferric fluoride at concentrations of 0.50, 0.25 and 0.50 per cent, respectively. All studies which used 5 applications per year gave significant reduction, while only 2 brushings per year showed little or no reduction in dental decay.

The use of an APF solution (1.23% F) brushed on 4 or 5 times a year in a toothbrushing drill produced only a small 15 per cent reduction in one study,[5] while another study with 9 supervised brushings in a two year period gave a higher (25%) reduction after 20 months.[11] One of the first investigations by the Public Health Service of APF solutions and gels took place in New Orleans in 1966,[24] but no significant reductions were found with either the APF solution or gel. A similar study conducted in Brazil however, did show a significant caries reduction with the APF solution and gel.[31] A prophylaxis prior to the topical application had no effect in the case of APF solutions, but did show an additive benefit when using the APF gels. The range of caries reduction was 20–30 per cent in non-fluoridated areas for either APF solutions or gels.

Self applications of APF prophylaxis pastes have not been as widely studied since the fluoride agent must be compatible with the abrasive system used. Mellberg and Nicholson[43] tested an APF paste containing silicon dioxide as the abrasive and ammonium silicofluoride as the fluoride source. When used semiannually as a self-applied prophylaxis paste, this APF paste produced a 21 per cent reduction in DFS.[49] The use of the same paste at 6 month intervals by professional application also produced 21 per cent less new DFS after two years.[14] An earlier study however with more frequent self-applications produced a non-significant 10 per cent inhibition of DMFS.[65]

Stannous Fluoride Regimes

Stannous fluoride containing prophylaxis pastes containing a lava pumice or zirconium silicate abrasive system have been more extensively studied.[3] The United States Navy currently uses a three agent regime of self-application of a 8.9 per cent SnF_2-lava pumice paste, followed by 10 per cent SnF_2 topical application and the daily use of a 0.4 per cent SnF_2 dentifrice. A 50–70 per cent reduction has been observed with this three-agent approach.[53] The use of a 17.5 per cent SnF_2 prophylaxis paste alone, however, produced a non-significant 12 per cent reduction in a separate study.[54] Another study using both a 8.9 per cent SnF_2 lava pumice paste and a 8 per cent SnF_2 solution showed no benefits when professionally applied only once a year.[30]

The 9 per cent SnF_2—zirconium SiO_4 abrasive system has received considerable attention by Muhler and co-workers.[46] In one study consisting of one 5-minute actual brushing of the teeth, a 9 per cent SnF_2 zirconium silicate paste produced an impressive 64 per cent DMFS reduction. In a fluoridated area however, Gunz[23] found no significant reduction from a single application.

A three-year study conducted by dental personnel from Indiana University and the U.S. Public Health Service tested the annual application of the 9 per cent SnF_2—$ZrSiO_4$ prophylaxis paste.[26] After three years only the examiner from Indiana University found a significant reduction of 23 per cent DMFS while the USPHS examiner found only a 15 per cent DMFS reduction. The authors point out that several studies using more frequent brushing intervals have consistently been positive.

In summary, the 15–20 per cent reduction with prophylaxis pastes is no better than mouthrinsing programs or regular use of fluoridated dentifrices and requires greater cost. If more frequent brush-ins are required to obtain positive results, the advisability of brush-ins as a public measure is dubious for caries preventive programs.

EXPERIMENTAL TOPICAL FLUORIDE AGENTS AND MODALITIES

Many methods of increasing the fluoride uptake, depth of fluoride penetration, and duration of retention have been suggested.[49] One such method uses a pretreatment of enamel with an APF solu-

tion for 2 minutes followed by a topical application of 0.5 per cent aqueous solution of SnF_2 for 2 minutes. *In vitro* results have shown that the combined applications give greatly increased resistance to subsequent acid dissolution.[56,58] Other methods use the pretreatment of enamel with a very weak phosphoric acid solution or with aluminum salt solutions. These pretreatments have been shown to increase the fluoride uptake of the subsequent APF application. Although these products are currently available, further studies are needed to document the clinical effectiveness.

Ammonium fluoride at pH 4.4 has been found to give greater fluoride uptake than APF.[7,70,72] *In vitro* studies with a 1 per cent solution of titanium tetrafluoride have shown that a glaze may be formed on the surface which renders the enamel more insoluable to acid dissolution.[48,59,73] In a recent clinical study using titanium tetrafluoride solution applied once a year, a reduction in DMFS of 50 per cent for titanium tetrafluoride and 33 per cent for APF when compared to the controls was found.[52] This appears to be a very promising approach to topical fluoride therapy.

Other vehicles and agents which are being investigated for use in preventive programs include chewing gum, cavity varnishes, pit and fissure sealants, fluoridated prophylactic cups and fluoride impregnated dental floss.[71] Laboratory studies have shown a significant fluoride uptake with the use of fluoride containing dental floss.[8,9] This floss may also reduce the prevalence of *Streptococcus mutans* on the proximal surfaces.[8] A new "thixotropic" gel has also been commercially marketed with claims of superior properties (Gel II-Pacemaker, Gelution-Unitek Corp.). Additional clinical studies will be needed to confirm the effectiveness of all these agents.

SUMMARY

Currently the most widely used topical fluoride agent is the APF gel. Fluoride gels produce cariostatic properties which are as effective as fluoride solutions and are more convenient to use in tray systems. Semiannual applications of SnF_2 and APF solutions or gels give approximately 30 to 50 per cent reduction in dental caries in sub-optimally fluoridated communities and 20 to 25 per cent reduction in fluoridated communities. The benefits are additive to other modes of fluoride administration including water fluoridation, fluoride rinses, or dentifrices.

In children with clean mouths, a pumice prophylaxis may not be an essential part of a topical fluoride treatment. If the children brush and floss their teeth prior to the topical fluoride it may result in less chairside time for the dentist and cost to the patients.

In adults who need periodontal scaling and cleaning of teeth but have minimal or no caries, a prophylaxis using fluoride containing paste may be adequate. However, the fluoride-containing prophylaxis paste should be allowed to remain in contact with the teeth for several minutes before rinsing.

Self-applications of a 0.6% APF gel or a 0.4% stannous fluoride gel daily is highly effective in the control of rampant caries and nursing bottle caries, and the prevention of postirradiation root caries. The fluoride may be either brushed onto the teeth or a tray may be used. The efficacy of infrequent (less than four times annually) self-applications of topical agents is questionable. The stannous fluoride multiple regime appears effective and has been utilized by the U.S. Armed Services. Some of the newer agents and modalities of topical fluoride may give more effective cariostatis in the future.

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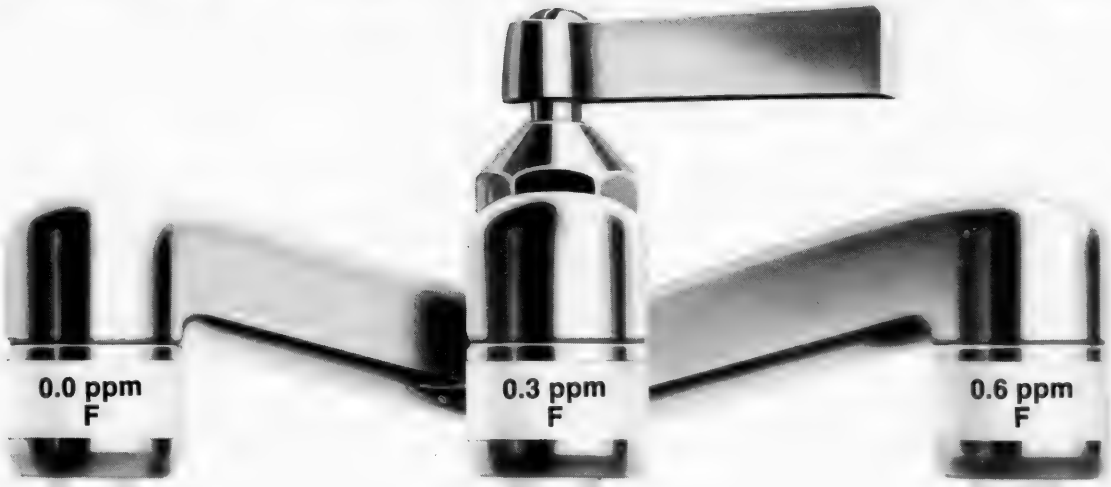

...so the vitamin/fluorides pediatricians prescribe may not give your patients the fluoride they need.

The fixed-dose vitamin/fluoride supplements that pediatricians prescribe for your patients can not be adjusted accurately to the fluoride content of your patients' drinking water. If a pediatrician tries to adjust fluoride dosage, he may be giving his patient too much or too little vitamin supplement. This is why dental authorities do not recognize vitamin/fluoride combinations as an effective means of supplying fluoride.

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Contraindications: LURIDE Lozi-Tabs are contraindicated when the fluoride content of drinking water contains 0.3 ppm F or more. LURIDE Half-Strength Lozi-Tabs and LURIDE Drops are contraindicated when the drinking water exceeds 0.7 ppm F. *Precaution:* Recommended dosage should not be exceeded since prolonged over-dosage may result in dental fluorosis. *Administration and Dosage:* 1. When drinking water contains less than 0.3 ppm F: age three and over, 1.0 mg. F per day; under age three, 0.5 mg. F per day.* 2. When drinking water contains 0.3 to 0.7 ppm F inclusive: age three and over, 0.5 mg. F per day; under three, 0.2 to 0.3 mg. F per day. 3. When drinking water contains over 0.7 ppm F, fluoride supplements are contraindicated. LURIDE is available in tablet strength of 1.0 mg. F, 0.5 mg. F, 0.25 mg. F, and as LURIDE Drops (each drop contain 0.1 mg. F). *Supplied:* Drops: 40 ml. drop-delivery plastic bottle. Lozi-Tabs chewable lozenge-type tablets: bottles of 120; bottles of 1000 and 5000 for dispensing only, available in cherry, lemon, lime, orange and rainbow assortment flavors. 0.5 mg. Lozi-Tabs tablets (half strength): bottles of 120, bottles of 1200 for dispensing only, grape flavored. 0.25 mg. Lozi-Tabs, bottles of 120, vanilla flavored. LURIDE—SF 1 mg. Lozi-Tabs: bottles of 120.

*Some dental authorities now recommend 0.25 mg. F daily under age 2.

[1]*Accepted Dental Therapeutics:* 241, 1973-1974. [2]Aasenden, R., and Peebles, T.C.: Effects of Fluoride Supplementation from Birth on Human Deciduous and Permanent Teeth, *Archs Oral Biol* 19:321, 1974. [3]Mellberg, J.R., Nicholson, C.R., and Law, F.E.: Fluoride Concentrations in Deciduous Tooth Enamel of Children Chewing Sodium Fluoride Tablets, *J. Dent Res* 51:551, 1972.

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References: 1. Data on file, Block Drug Company, Inc. 2. Abstract of the Symposium on Mechanisms of Pain and Sensitivity in the Teeth and Supporting Tissues, Fairleigh Dickinson University School of Dentistry, Nov. 12-13, 1973, p. 15. 3. Goldman, H. M. and Cohen, D. W.: An Introduction to Periodontia, Fourth Edition, The C. V. Mosby Company, St. Louis, 1969, p. 74.

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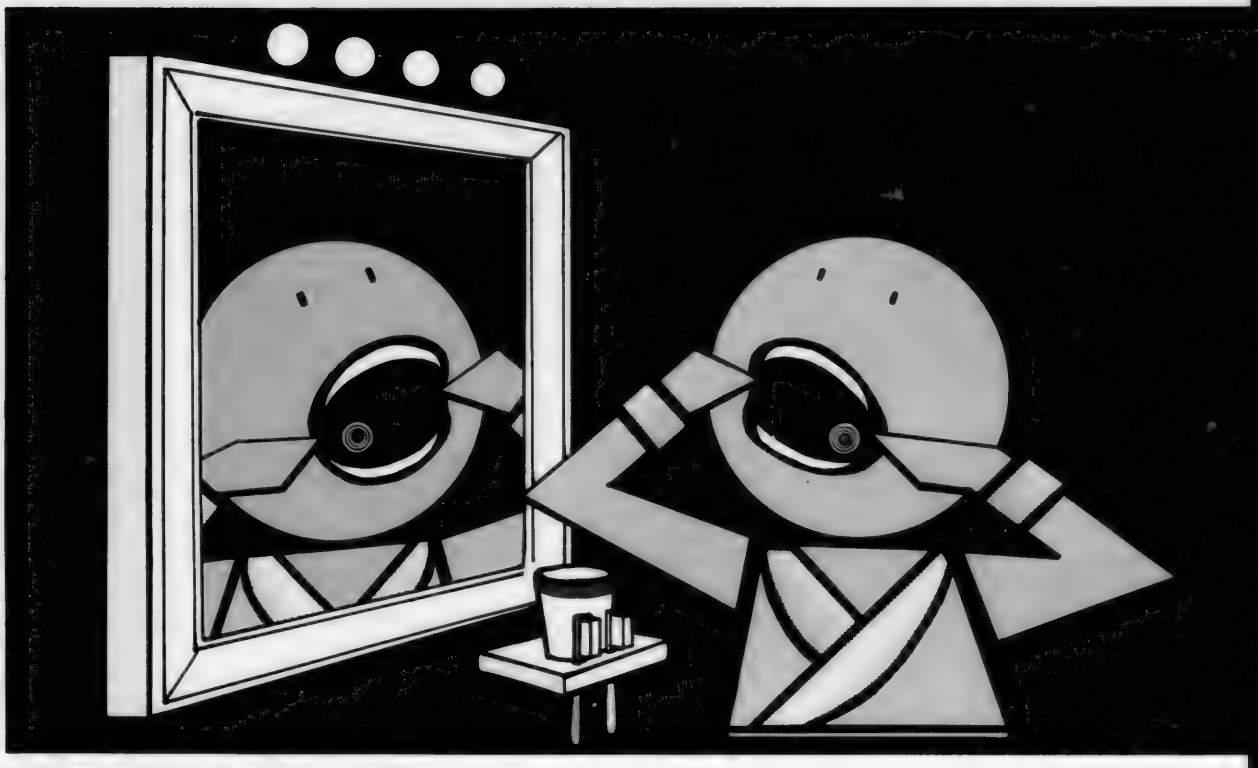

Self-Examination for Cancer. See page 47

- ☐ Preventive and Interceptive Orthodontics
- ☐ Fluoride Rinsing
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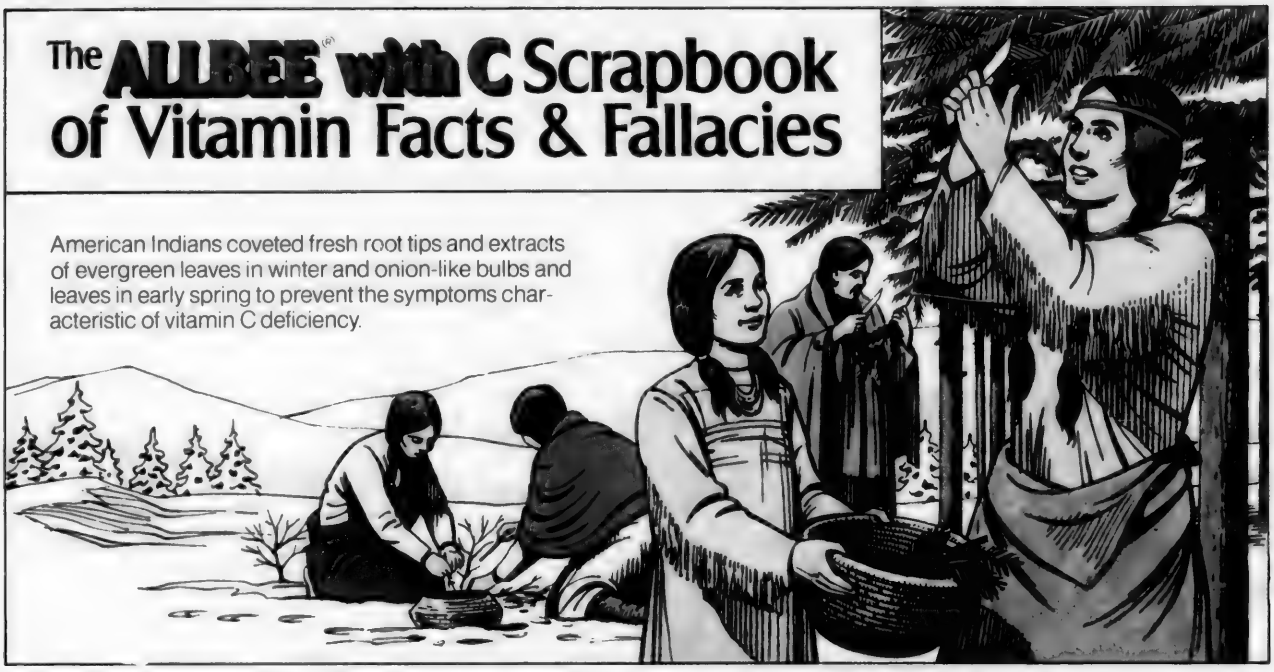

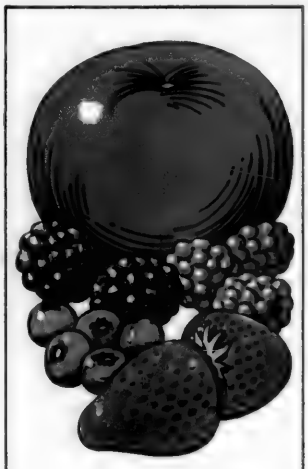

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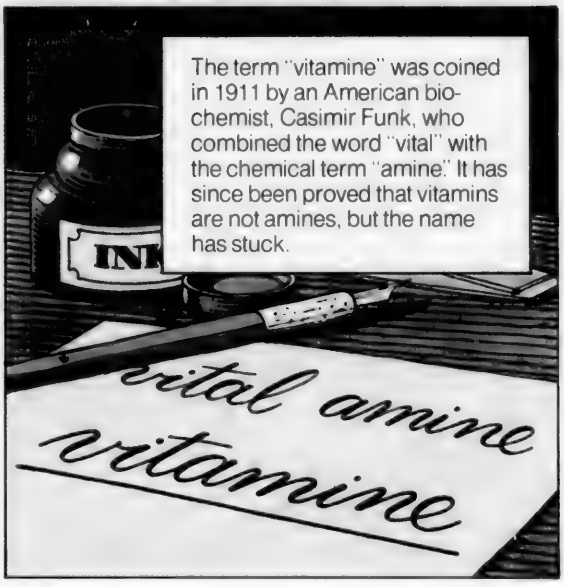
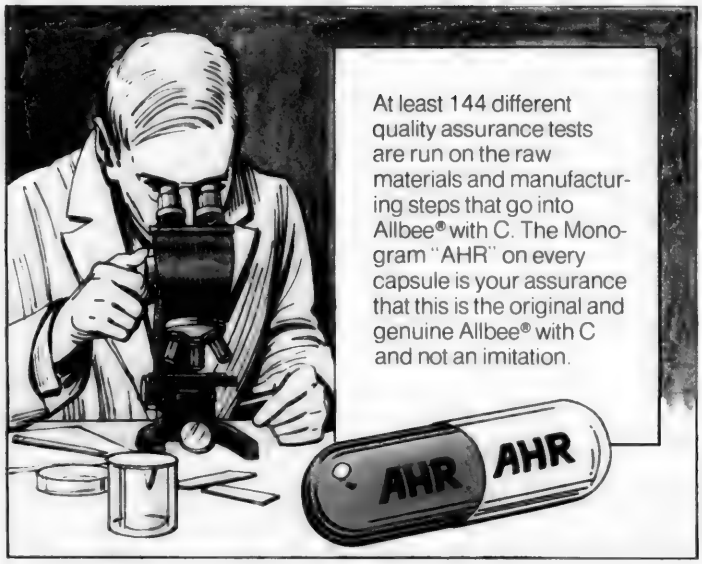


The term "vitamine" was coined in 1911 by an American biochemist, Casimir Funk, who combined the word "vital" with the chemical term "amine." It has since been proved that vitamins are not amines, but the name has stuck.



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preventive dentistry

Vol. 4 • No. 5 September-October 1977

contents

7 Preventive and Interceptive Orthodontics: A Critical Review and the Results of a Clinical Study

Julian D. Freeman, D.D.S.

25 Fluoride Rinsing: A School-Based Dental Preventive Program

Louis W. Ripa, D.D.S., M.S., Gary S. Leske, D.D.S., M.S., M.P.H., and Warren G. Lowey, Ph.D.

31 Arch Length

Arnold J. Malerman, D.D.S.

39 Tooth Eruption and Ankylosis

Irving W. Eichenbaum, D.D.S.

47 Early Detection of Head and Neck Cancer Using Oral/Facial Self-Examination

John C. Grabau, M.P.H. and Stanley J. Scott, D.D.S.

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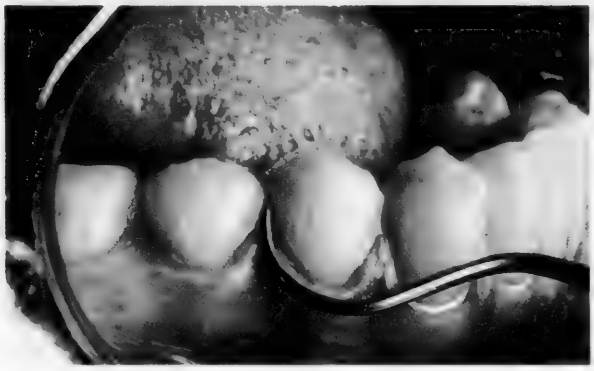

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A separate fact sheet (250 words maximum) should be included specifying the article's most important facts or findings. It is suggested that research papers be divided logically into sections such as: Background, Method, Materials, Results, and Discussion.

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Preventive and Interceptive Orthodontics:

A Critical Review and the Results of a Clinical Study

Julian D. Freeman, D.D.S.*

It has been a long standing dream of dentists, even before there was a specialty of orthodontics that methods would be available to prevent irregularities of the teeth and dentofacial deformities. As the field of orthodontics has developed over the past 100 years, there has been less and less hope held for discovering a "magic bullet" which would largely eliminate the need for complete corrective orthodontics. It is the purpose of this paper to examine some of the issues involved in this complex and controversial area known as preventive and interceptive orthodontics. Also, the findings of a 3½ year descriptive clinical study is presented.

HISTORICAL REVIEW AND REVIEW OF LITERATURE

It is not surprising that 19th century dentists, before the era of Mendel and Darwin, held an absolute and perfectionist view of nature. This nonbiologic and unscientific view perhaps reached its most creative expression in the writings of Bonwill,[7] regarding ideal articulation of the natural dentition. He believed that every part of the body conformed to a law that was in harmony with geometry, physics, and mechanics. He was a true man of the industrial revolution in that there was an ordered universe governed by the laws of Newton and mechanics. Hence, non-ideal occlusion in Bonwill's view was thought to be a perversion of nature. In this approach, all individuals were assumed to be endowed with the potential for ideal or perfect traits and that any deviation from perfection was simply the result of some interference with nature's master plan.

It is interesting to note that as early as 1870, McQuillen[38] described a familial tendency toward irregularities of the teeth; however, there is no evidence that any of his contemporaries took these findings seriously or that McQuillen himself had any real understanding of the full significance of his theories. This was evident at the turn of the century when Angle[2] and Wallace[66] held that abnormal function was the principle causative factor in preventing the full expression of the individual's potential for perfect "balance and harmony" in the dentofacial structures. The removing or adding of functional stimulation was thought to be the solution to the problem of malocclusion. This idea reached its peak during the late 1930's in the writings of Rogers.[53–55] It is still a point of view with a number of adherents of which perhaps the most notable is Fränkel.[17–20] The work of Stockard and Johnson,[59] with the cross breeding of dogs in the 1940's almost totally reversed the thinking of orthodontics regarding the heritability of dentofacial traits. Further research utilizing the twin study method in the 1950's[27,37] gave added strength to the widely accepted belief that malocclusion is either directly or indirectly the result of genetic factors. Research in the 1960's indicated that the mode of inheritance of dentofacial traits actually followed a complex, polygenic pattern.[56] From this information a fatalistic attitude developed in clinical orthodontics. For at least the past 25 years, orthodontists have, with some justification, utilized a mechanistic approach rather than a presumably biologic approach to treating malocclusion. It is most interesting to observe that as we learn more about the mechanisms and determinants of craniofacial growth and development, there is considerable appeal in Moss'[41–44] functional matrix concept. This pattern of thinking is making some clinical orthodontists re-examine the earlier approaches to interceptive treatment that are still popular in certain parts of Europe.[21,25,51,60]

As early as the first century A.D., Celsus[9] wrote about the efficacy of extracting over-retained primary teeth in order to allow the permanent teeth to erupt into more favorable positions in the arch. Thus, the importance of a normally developing transitional dentition for the normal development of the permanent dentition has been known for at least 1976 years. Although space maintenance had been popularized by Sippy[57,58] in the late 20's and Willett[69] in the early 30's it was not until the study of Ungar[65] in 1938 that it was definitively shown that arch perimeter loss was due to the premature loss of primary teeth. Ast's study of the Newburgh, New York population reported significantly fewer lost teeth than the Kingston, New York population and a reduction of malocclusion of approximately 6.7%.[3] This was attributed to a lessened DMF caries experience and reduced premature loss of permanent molars in the water fluoridated area.

The single most important principle underlying all of the other concepts regarding preventive and interceptive orthodontics is the simple truth that it is absolutely essential to have a normal primary and "mixed" dentition as well as a normal transition between the primary, "mixed," and permanent dentitions in order to ultimately have a normal adult dentition. If man were not diphyodont there would be little potential for preventive and interceptive orthodontics. Not only is it a fact that man has more than one set of teeth an important consideration, but the fact remains that the time interval between the development of the primary dentition and the permanent dentition is a long period (approximately 11½ years) is also important. During this long period there is much time for untoward changes to take place in the positions and functions of the unerupted and erupted permanent teeth.

Perhaps the second most important underlying concept of preventive and interceptive orthodontics is that the arrangement and configuration of the teeth and dental arches are in a highly delicate yet dynamic equilibrium, which can easily be disturbed by interfering with the forces which maintain this equilibrium. To make this matter even more complex, the dental apparatus which is in delicate balance is also growing, developing and maturing

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at the same time. During this 11½ year development period, teeth are continuously erupting. Although, the actual eruptive force has never been measured, from clinical experience it appears that only a fraction of a gram is enough force to inhibit tooth eruption. Other forces involved in this equilibrium are the muscle forces, the forces of occlusion, the gingival fiber apparatus and probably others that are not too well understood. In essence, preventive and interceptive orthodontics is the guidance and supervision of growth and development of the dentition. The sequence of eruption, timing of eruption and the normal dimensional changes in the development of the dentition are all important considerations. Early loss of primary teeth is the most common local disturbance leading to a malocclusion.[8] Normally, there is just enough room in the dental arches for the successional dentition. The early correction of certain types of malocclusions, *i.e.* crossbites, is believed to enhance the development of the dentition, often eliminating the need for future treatment.

If it has become axiomatic in dental medicine that in order to obtain a normal permanent dentition it is essential to have a normal transition from the primary dentition, why has the topic of preventive and interceptive orthodontics become so controversial? As always, controversy stems from exaggerated claims at both poles. One group claims that almost all malocclusions can be prevented or intercepted,[63] while another group counters that almost no malocclusions are preventable.[15] Logic alone dictates that the truth lies somewhere between these polar views. Much of the problem arises from the literature which is replete[4–6, 10–14,16,24,28,30–36,39,40,45,47,50,61,62,64,67,68] with articles describing "early treatment" or interceptive orthodontics, whether it be serial extraction, class II therapy, class III therapy, correction of crossbites, or habit control. Yet, there has only been one long term longitudinal follow-up study describing the methods of treatment and which segment of the population that truly benefitted from preventive and interceptive orthodontics. This was reported by Popovich and Thompson in 1972.[45] In addition, part of the controversy lies in the requiring of more precise definitions and methods of patient evaluation, since each author presents a slightly modified view of interceptive orthodontics based on his own clinical success or failure.

It is the author's purpose to offer operational definitions of preventive and interceptive orthodontics, demonstrate clinical methods used with these definitions and offer descriptive epidemiologic data derived from a clinical study which might help others estimate the need and demand for this type of service. The results reported here are the experience over a three and one half year period with a preventive and interceptive orthodontic teaching clinic for the pre-doctoral program at the University of Pennsylvania School of Dental Medicine.

DEFINITIONS

According to Graber[22] preventive orthodontics is: "The primary charge to the dentist who would render preventive orthodontic service is that he strive to maintain a normal occlusion for that particular age. . . . The preventive group includes all patients in a patient education program. Such things as space control, space maintenance and space regaining, maintenance of a quadrant tooth-shedding time table, functional analysis and oral habit check-up, muscle exercises, caries control, prevention of Milwaukee brace damage, and so forth, are part of the preventive group."

As concerns interceptive orthodontics: "Interceptive procedures are required for developing basal dysplasias (orthopedic guidance), cleft palate problems, anterior diastemas, habit problems, arch length deficiency problems, and so forth. Here such things as habit appliances, space regainers, occlusal equilibration, slicing, stripping and serial extraction procedures are important. . . ."

In further differentiating preventive from interceptive orthodontics Graber goes on to state: "For preventive orthodontics, the occlusion was within normal limits at that time, and those procedures were intended to keep it that way. Interceptive orthodontics actually "intercepts" a malocclusion that has already developed or is developing, and the goal is to restore a normal occlusion. . . . The difference between preventive and interceptive orthodontics lies in the timing of services rendered. In interceptive orthodontics the dentist is dealing with malocclusion as a fait accompli, at least to a minor degree. If he renders the proper service with dispatch, autonomous adjustment will restore normal occlusion. If he waits too long, then there is no question that he must resort to the limited corrective orthodontic procedures."

Popovich and Thompson's[49] definitions are similar to Grabers', but grouped somewhat differently. For example, preventive orthodontics is any action taken to preserve the integrity of a normal occlusion (all aspects of preventive dentistry). Interceptive orthodontic treatment is defined as procedures that eliminate or reduce the severity of a developing malocclusion. Interceptive orthodontic treatment included habit consultation, consultations concerning operative work, removal of supernumerary teeth, occlusal equilibration, slicing of mesial surfaces of deciduous cuspids, insertion of fixed and removable space maintainers, space regainers, labial shields, frenectomies, swallowing exercises, and extraction of deciduous and permanent teeth as part of serial extraction procedures, over-retention of deciduous teeth and pathology. Additionally interceptive, plus compound treatment was made up of all forms of interceptive methods and more complex treatment which included bite planes, expansion plates, monoblocs, labial or lingual arch wires, cervical headgear, partial bands, full bands upper and/or lower. The other category of compound treatment included all the more complex forms of treatment without any interceptive procedures.

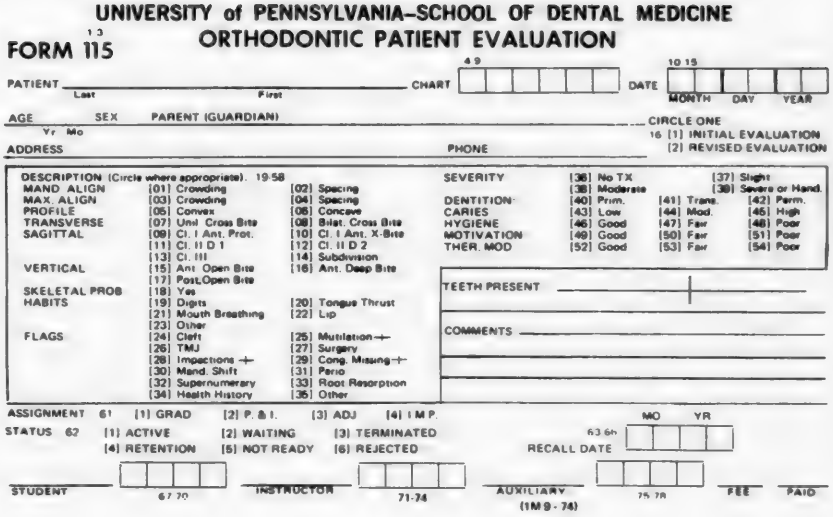
Popovich and Thompson found that almost 73% of the children with Class I malocclusion have a balanced skeletal pattern, and therefore a higher percentage of them should respond to interceptive treatment alone. This was supported when 89.5% of those patients responding to "interceptive procedures only" were Class I (extraction and non-extraction cases). If one were to include only the Class I non-extraction cases then the percentage that responded favorably would be approximately 74%.

With this information already available, it was possible to become more selective in the case types to be accepted into our preventive and interceptive orthodontic program. As a result, from the outset it was decided that the following characteristics had to be present in the selection of patients who would benefit from preventive and interceptive orthodontic procedures: (1) the patient had a primary or transitional dentition (2) the patient was still growing (3) there was no basal bone

dysplasia (Class I pattern) (4) there was only one occlusal characteristic present (according to the orthogonal analysis) (5) there would be a minimal appliance therapy (if fixed appliances, no more than 6 bands in either arch) (6) short treatment time anticipated (approximately one year) (7) at the end of treatment the occlusion would be acceptable (8) no further treatment would be necessary to gain acceptable occlusion (9) the malocclusion was not potentially self-correcting.

More specifically, the following types of problems had to be defined for preventive and interceptive orthodontics. The term preventive orthodontics applies to the elimination of factors which may lead to malocclusion in an otherwise normally developing dentition. Along with preventive and restorative dentistry, space maintenance must be considered when there is premature loss of primary molars, first permanent molars, or any of the permanent incisors. In addition, supernumerary, ankylosed or over retained primary teeth should be extracted in order to insure the normal eruption of the permanent successors. Guidance of eruption is considered preventive orthodontics in minimally crowded dentitions. This includes the prediction as well as the implementation, whether it be the slicing of the interproximal surfaces of the primary teeth according to Hotz[29] or the insertion of a lingual arch according to Nance.[46]

In contrast, interceptive or corrective orthodontics pertains to an already existing malocclusion. It is important to state emphatically that the preventive and interceptive orthodontics being discussed here should not be confused with what modern orthodontists frequently refer to as "early treatment" which is usually understood that a second phase of treatment will be required and that the goal of the first treatment phase is to merely lessen the severity of the problem. In our view, the goal of preventive and interceptive orthodontics is to totally eliminate the need for further treatment. This is the reason for not including extraction, Class II, or Class III modalities as outlined by Popovich, Thompson and Graber since these invariably require a second phase of treatment. It therefore becomes necessary to modify and redistribute the "interceptive only" category in order to achieve our own objectives. For example, alignment problems include space maintaining, and space regaining


UNIVERSITY of PENNSYLVANIA–SCHOOL OF DENTAL MEDICINE

FORM 115 ORTHODONTIC PATIENT EVALUATION

PATIENT (Last, First) CHART DATE (Month, Day, Year)

AGE (Yr, Mo) SEX PARENT (GUARDIAN) CIRCLE ONE [1] INITIAL EVALUATION [2] REVISED EVALUATION

ADDRESS PHONE

DESCRIPTION (Circle where appropriate).

MAND. ALIGN	[01] Crowding	[02] Spacing	SEVERITY	[36] No TX	[37] Slight	[38] Severe or Hand.
MAX. ALIGN	[03] Crowding	[04] Spacing		[38] Moderate		
PROFILE	[05] Convex	[06] Concave	DENTITION	[40] Prim.	[41] Trans.	[42] Perm.
TRANSVERSE	[07] Unil. Cross Bite	[08] Bilat. Cross Bite	CARIES	[43] Low	[44] Mod.	[45] High
SAGITTAL	[09] Cl. I Ant. Prot.	[10] Cl. I Ant. X-Bite	HYGIENE	[46] Good	[47] Fair	[48] Poor
	[11] Cl. II D 1	[12] Cl. II D 2	MOTIVATION	[49] Good	[50] Fair	[51] Poor
	[13] Cl. III	[14] Subdivision	THER. MOD	[52] Good	[53] Fair	[54] Poor
VERTICAL	[15] Ant. Open Bite	[16] Ant. Deep Bite				
	[17] Post. Open Bite					
SKELETAL PROB	[18] Yes					
HABITS	[19] Digits	[20] Tongue Thrust				
	[21] Mouth Breathing	[22] Lip				
	[23] Other					
FLAGS	[24] Cleft	[25] Mutilation				
	[26] TMJ	[27] Surgery				
	[28] Impactions	[29] Cong. Missing				
	[30] Mand. Shift	[31] Perio				
	[32] Supernumerary	[33] Root Resorption				
	[34] Health History	[35] Other				

TEETH PRESENT

COMMENTS

ASSIGNMENT 61 [1] GRAD [2] P. & I. [3] ADJ [4] I.M.P.

STATUS 62 [1] ACTIVE [2] WAITING [3] TERMINATED [4] RETENTION [5] NOT READY [6] REJECTED

RECALL DATE (MO, YR)

STUDENT 67-70 INSTRUCTOR 71-74 AUXILIARY (1M9-74) 75-78 FEE PAID

FIG. 1. Computer form #115.

when preventive measures were not started at the proper time. This refers to the posterior as well as the anterior segments of the dentition. Anterior diastemata were consolidated when there was insufficient room in the arch form for an erupting permanent tooth. Generalized anterior inter-dental spacing was consolidated in Class I anterior protrusions, in order to achieve a more normal overjet configuration. Although commonly thought of as existing solely in the maxilla, the mandibular dentition can also exhibit a Class I type of protrusion with spacing. In addition to anterior protrusions, anterior crossbites and ½ cusp Class II molar relationships are the other occlusal mal-relationships corrected in the sagittal plane. This should not be confused with crossbites in the buccal segments which encompass the transverse plane, being either unilateral or bilateral in nature. The vertical component comprises anterior deep bites, posterior open bites, and anterior open bites. Frenectomies were not performed.

Although these categories describe the occlusal relationships that are most amenable to preventive and interceptive orthodontics, other factors were considered in the selection of patients into the Clinic. The oral hygiene had to be reasonably good and any hard or soft tissue pathology had to be under control. Also, the expressed interest and potential cooperation of the patient was an extremely important consideration.

METHOD OF PATIENT EVALUATION AND TREATMENT

Once the criteria for patient selection had been finalized, the next step was the establishment of a reliable means for patient evaluation and an efficient method for the retrieval of this computerized information. This was significant since the evaluation itself fulfilled three functions simultaneously, *i.e.* providing a teaching format for undergraduate and graduate students in the recognition of malocclusion; providing a patient population for the various Orthodontic Clinics within the department; and to provide epidemeologic information about the characteristics of occlusion as presented by a demand population within a 50 mile radius of the Philadelphia metropolitan area. The reliability of the Orthogonal Analysis was demonstrated by Rekow[52] who stated that decisions based on the Orthogonal Analysis alone, proved to be 77% accurate compared with the decisions made after complete orthodontic records were analyzed. Since Rekow did not utilize any initial radiographs, it was felt that this percentage could be augmented with the taking of a panographic film of each patient to be evaluated. When coupled with a computerized format of the Orthogonal Analysis (#115) (Fig. 1) a more accurate patient profile would become obtainable which could accurately be retrieved at a later date. Although these items are critical for the evalua-

UNIVERSITY OF PENNSYLVANIA
DEPARTMENT OF ORTHODONTICS
PRELIMINARY ORTHODONTIC EVALUATION

Child's Name_____Date_____

YOUR CHILD HAS A:

- ☐ Good Occlusion (Correct bite)
- ☐ Slight Malocclusion (Irregularities of the teeth or jaws)
- ☐ Moderate Malocclusion
- ☐ Extreme Malocclusion

THE MALOCCLUSION IS CHARACTERIZED BY:

- ☐ Crowding
- ☐ Spacing
- ☐ Cross-bite
  - Anterior (Front)
  - Posterior (Back)
- ☐ Protrusion
- ☐ Deep Bite
- ☐ Open Bite
- ☐ Other_____

WITH ORTHODONTIC TREATMENT (BRACES) YOUR CHILD WOULD:

- ☐ Not profit in the long run
- ☐ Profit a little
- ☐ Profit
- ☐ Profit greatly

IF TREATMENT IS NEEDED IT SHOULD BE STARTED IN:

- ☐ 6 months
- ☐ 1 year
- ☐ 2 years
- ☐ 3 or more years

Your child's evaluation form will be filed with those children seeking orthodontic care in our department.

THE CHANCES OF YOUR CHILD BEING CALLED FOR FUTHER EVALUATION ARE:

- ☐ No chance
- ☐ Fair
- ☐ Good
- ☐ Excellent

If not called by us by_____consider seeking care from a private orthodontist.

The average cost of orthodontic treatment in our clinic is $900.00

OTHER DENTAL CARE THAT WE FEEL YOUR CHILD SHOULD HAVE AT THIS TIME:

- ☐ Treatment for dental caries
- ☐ Oral Hygiene instruction

Initials_____

FIG. 2. The written report of the orthodontic evaluation given to the parent at the conclusion of the examination, a copy of which is retained in the patient's folder.

tion process, other additional forms are utilized.

Sequentially, at this first visit, the health history form is completed after which the panoramic radiograph is taken. A third year dental student performs the initial clinical examination, completing the #115 form in pencil. These pencil marks are converted to ink by one of the orthodontic faculty members as he reviews the student's selections. The only section not completed is that labelled "disposition." The student then apprises the parent of his findings and also gives the parent a written report in language that a lay person is able to understand (Fig. 2). On a weekly basis the orthodontic faculty member in charge of patient selection then completes the disposition section. The information is now ready to be key punched and stored in the IBM 3600 computer data bank. This decision process is made easier by the rather homogeneous assessment of the criteria since all 6 faculty members attended the same post-doctoral orthodontic program; all having a similar philosophy and outlook. Once a patient is selected for treatment in the Preventive and Interceptive Orthodontics Clinic, complete records are taken by specially trained dental auxillaries. These include models, a panographic radiograph with supplemental films, a lateral cephalogram, extra-oral polaroid photographs, and intra-oral kodachrome films. Again, a third year dental student does the case work-up as outlined in the appropriate chapters of Graber's text.[22] The case is then presented to the assigned orthodontic faculty member. This is standard procedure and performed on all patients prior to the commencement of any mechano-therapy.

After analyzing the records, a treatment plan is formulated for those patients who could benefit from preventive and interceptive orthodontics. The integration of other dental services becomes crucial so as not to needlessly delay the starting of treatment. The patient's dental health continuously improves at a steady, unimpeded, coordinated schedule. Annual records are compiled during therapy.

The design of the appliances must be efficient, uncomplicated, and durable, since the Preventive and Interceptive Orthodontic Clinic provides the teaching format for the third year dental students. In order to minimize time that might be spent on poorly fabricated appliances and maximize the time allocated for the treatment of patients, the Clinic employs two full time orthodontic laboratory technicians. Virtually all the appliances are constructed indirectly. Fixed, bilateral, soldered lingual arches are used for space maintaining situations (preventive orthodontics), regardless of unilateral or bilateral loss of primary molars (Fig. 3). In the maxillary dentition the design is after Nance. The fixed soldered method of treatment was sustained by Hill, C.J. *et al.*[26] when comparing all varieties of space management: *i.e.* fixed, removable, unilateral and bilateral appliances. Relative ease of clinical manipulation, chair time and durability were the reasons attributed to the soldered fixed lingual arches overall success rate. Hawley removable appliances designed with finger springs or jackscrews, were usually used to regain and close space. Removable appliances with posterior bite planes incorporating expansion screws that were activated once every three days, resolved most of the bilateral maxillary palatal crossbites (Fig. 4). Unilateral crossbites were

(continued on page 12)

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Composition: Each teaspoonful (5 ml.) contains 1.0 milligram fluoride ion (from 2.2 mg. sodium fluoride) in an M/10 phosphate solution at pH 4 in lime, orange or cherry flavor. **Contraindications:** Do not swallow in areas where the drinking water contains more than 0.7 ppm F. **Precaution:** Recommended systemic dosage should not be exceeded, as prolonged overdosage may result in dental fluorosis. **Dosage and Administration:** Children age 3 and over—preferably at bedtime after brushing teeth. In areas where drinking water is devoid of fluoride (0-0.3 ppm), one teaspoonful (5 ml.) to be rinsed around and between the teeth for one minute before swallowing. When drinking water contains 0.4 to 0.7 ppm F, reduce dose to one-half a teaspoonful. When drinking water contains more than 0.7 ppm F, one teaspoonful (5 ml.) to be rinsed around and between teeth for one minute, *then expectorate.* Do not eat, drink or rinse mouth for at least 15 minutes afterward. **How Supplied:** 250 ml. and 500 ml. plastic bottles. Choice of orange, cherry and lime flavors.

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[1]Aasenden, et al., Effects of Daily Rinsing and Ingestion of Fluoride Solutions Upon Dental Caries and Enamel Fluoride, *Arch. Oral Biol. 17:* 1705-1714, 1972. [2]Frankl, S.N., et al., The Topical Anticariogenic Effect of Daily Rinsing with an Acidulated Fluoride Phosphate Solution, *JADA 85:* 1972. [3]Finn, S.B., et al., The Clinical Cariostatic Effectiveness of Two Concentrations of Acidulated Phosphate-Fluoride Mouthwash, *JADA 90:* 1975.

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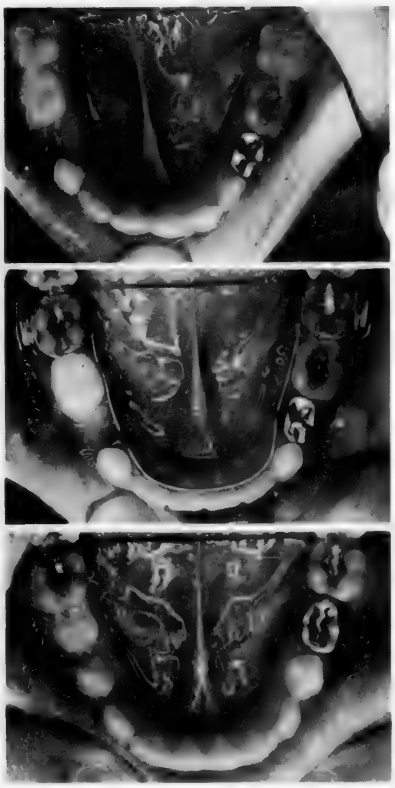
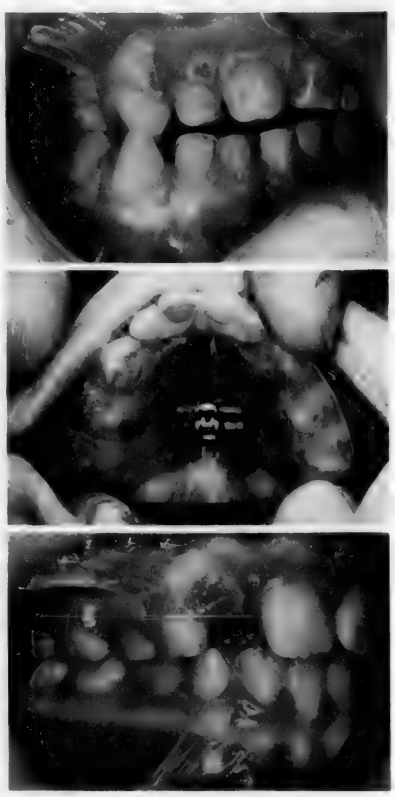


FIGS. 3A–C. Preventive orthodontics: A (Top) The premature loss of the mandibular left primary first molar. B (Center) The insertion of a bilateral, fixed, soldered, lingual, arch. C (Bottom) The removal of the lingual arch upon the eruption of the mandibular left permanent first premolar.

(continued from page 10)
corrected with cross elastics, Hawley appliances with finger springs; or springs soldered to a removable lingual arch when coupled with space management. Again, Hawley appliances with finger springs for crossbites (Fig. 5) and elastic hooks for intra-oral elastics corrected those malocclusions in the sagittal plane (Fig. 6). For the anterior open bite cases, treatment ranged from reason and logic, to removable habit reminders (Fig. 7), to fixed habit reminders, to myo-functional therapy, and, if needed, psychological counseling. At no time were sharp barbs, rakes, or any means of physical punishment encouraged.

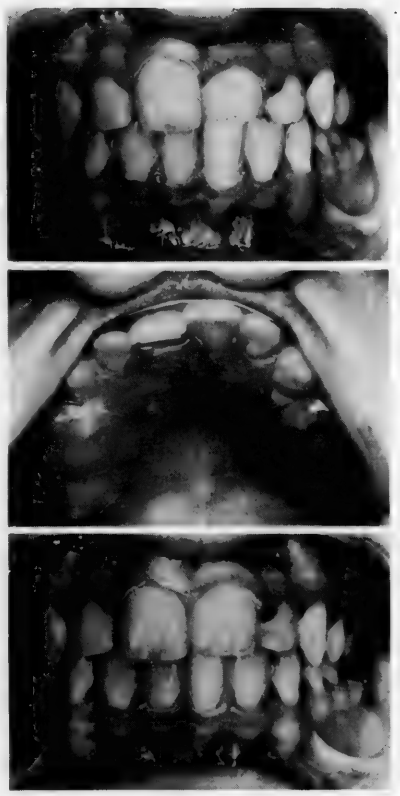
In all cases, retention depended on the original dental configuration and varied from no retention, to removable retainers, fixed retainers or various periodontal procedures.



FIGS. 4A–C. Interceptive orthodontics: A (Top) The affected side of a maxillary bilateral palatal cross-bite in the primary dentition. B (Center) The insertion of a removable appliance utilizing an expansion screw and a posterior bite plane. Note, that there are no clasps. C (Bottom) The correction and post-retention of the cross-bite. Note the normal eruption of the permanent first molars.

FINDINGS

Over the past three and one half years 4200 patients comprising a demand population were evaluated for the potential inclusion in the preventive and interceptive orthodontic program offered at the University of Pennsylvania School of Dental Medicine. Although the clinic is located in Philadelphia, patients came from the outlying suburban communities of Philadelphia and Southern New Jersey, reaching as far as Wilmington, Delaware; Atlantic City and Trenton, New Jersey; and Harrisburg, Pennsylvania. A demand population denotes the desirability of orthodontic services because this group has either been informed by a professional person; or recognizes independently that an orthodontic problem will develop or that an orthodontic problem already exists.



FIGS. 5A–C. Interceptive orthodontics: A (Top) A Class I anterior cross-bite of the maxillary left permanent central incisor. B (Center) The insertion of a maxillary hawley appliance utilizing a posterior bite plane and a finger spring to the affected tooth. C (Bottom) The correction and post-retention of the cross-bite.

This became evident in the total evaluations, since approximately 98% of all those examined were judged to require some form of orthodontic intervention.

Table 1 represents the numbers and percentages of the dentitional types of the children who presented for evaluation. 65.5% were already in the permanent dentition, too late for any preventive and interceptive orthodontic measures. At this point in time, the problems encountered could best be resolved by the conventional, corrective method of orthodontic treatment. Still, 34.4% presented in the primary or mixed dentitions in the hope of mitigating the need for full banded therapy at a later date. However, this was not to be realized as seen in Table 2. Of those presenting in the primary or mixed dentitions 81.1% would eventually profit from full banded therapy whether it be in two phases, designed to coincide with the pre-pubertal

(continued on page 14)

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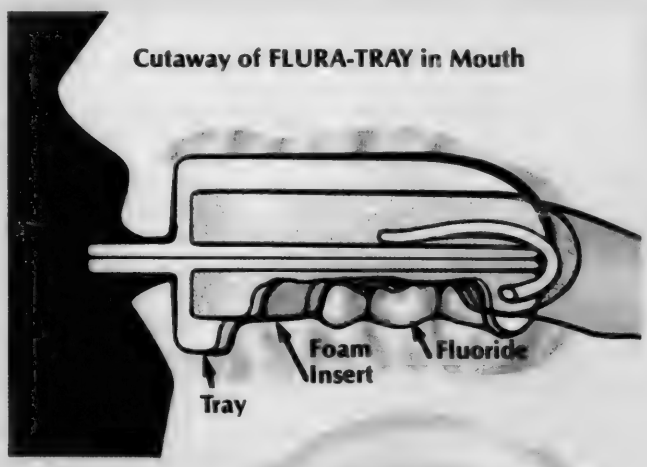

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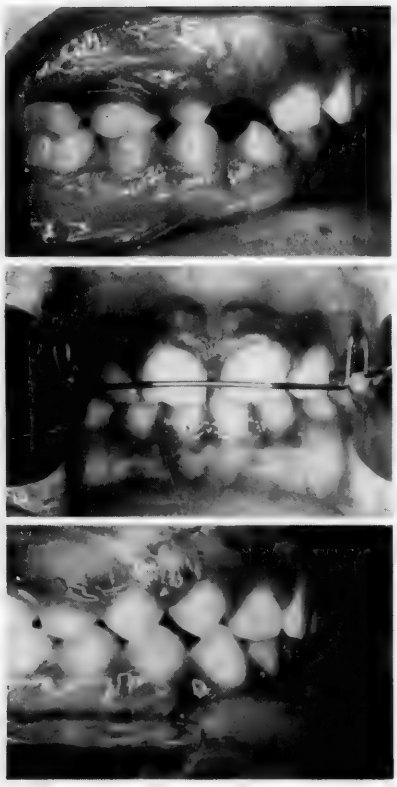


FIGS. 6A–C. Interceptive orthodontics: A (Top) A Class I anterior protrusion. B (Center) The insertion of the maxillary hawley appliance. C (Bottom) The correction and post-retention of the protrusion. Note the eruption of the permanent teeth.

(continued from page 12)
growth spurt, or started when all growth had terminated. Another 4.6% would not profit from any treatment. The remainder, 14.3% would indeed profit from preventive and interceptive orthodontics as previously defined.

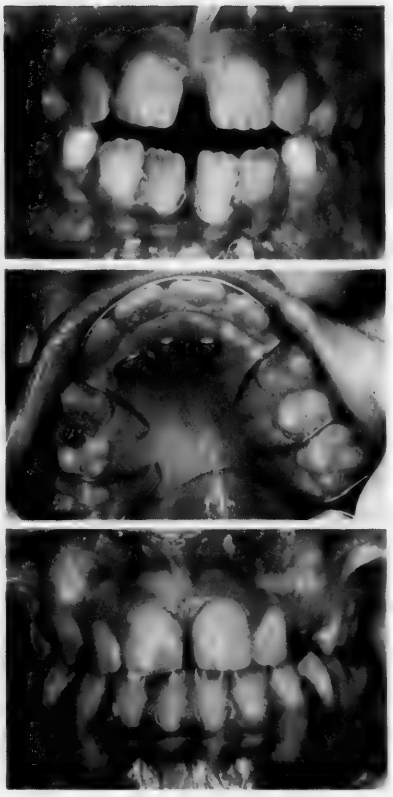
Of the 217 patients accepted into the preventive and interceptive orthodontic clinic, 156 did not require any further treatment, 10 patients discontinued treatment, while the remaining 51 were transferred into the postgraduate clinic for the completion of treatment.

Table 3 outlines the number of successfully treated patients and indicates the percentages according to the types of orthodontic problems encountered. Incorporated into the alignment category is the space management of preventive orthodontics as well as the space regaining aspects of interceptive orthodontics. The range of case types is more or less equally distributed between alignment (26.3%), sagittal (26.9%) and transverse (25.6%). Interceptive orthodontic problems in the vertical plane accounted for (16.7%). The category "other" (4.5%) pertains to those cases that have more than one occlusal malrelationship, but still responded to interceptive orthodontics. In addition, Table 3 enumerates the most prevalent characteristic of the total within each plane. For example, the most common interceptive measure concerning alignment is space regaining or closure 11.6%. The majority treated under the sagittal category would be Class I anterior protrusion 16.0% while unilateral crossbites comprised 16.0% of the interceptive approaches in the transverse dimension. The anterior open bite group 16.0%, almost completely accounted for the most successful treatment in the vertical dimension.

Preventive and interceptive treatment for the various case types cannot uniformly be applied to all ages. As can be seen in Table 4 from the totals of each age group, the 7 to 9 year olds received the greatest success; 93 out of 156 (57.9%). That is not to say that certain preventive and interceptive measures should be delayed until this time. For example, 30 children were treated in the four to 6 year old age group. Preventive orthodontics, space maintenance and guidance of eruption, accounted for 9 children (30%) and 10 children (33⅓%) had their posterior crossbites corrected. However, a greater variety of occlusal malrelationships within each category were amenable to preventive and interceptive orthodontics as evidenced by the close grouping of numbers and per cent of the problems treated during the ages from 7 to 9. These percentages ranged in the low to high 20's: sagittal being 28.0%, transverse 24.7%, alignment 21.6%, other 4.3%. Although rather evenly distributed, fewer cases were selected for treatment in the 10 to 12 group and still fewer in the 13 to 15 year old interval.

DISCUSSION

In establishing the diagnostic criteria for those patients who would benefit from preventive and interceptive orthodontics, it was most helpful to incorporate the experiences of Popovich and Thompson. As indicated previously they had found that 73% of the children with a Class I malocclusion have a balanced skeletal pattern which should respond to "interceptive only" treatment. As was shown, 89.5% of



FIGS. 7A–C. Interceptive orthodontics: A (Top) A Class I open bite malocclusion. B (Center) The insertion of a maxillary hawley habit reminding appliance. Note the innocuous nature of the palatal crib. C (Bottom) The correction and post-retention of the Class I anterior bite.

this type of treatment was carried out in the class I extraction and non-extractions. If one were to further refine this sample to eliminate the extraction therapy which invariably requires a phase of full banded orthodontics, the percentage of success is still high at 74%. With this in mind it was necessary to slightly modify Popovich's definitions. For example, what he called "interceptive only"; consultations, space management, removal of primary teeth and supernumary teeth, and the slicing of interproximal surfaces of primary teeth, can be considered preventive orthodontics along with all aspects of preventive dentistry. He considers the removal of permanent teeth for serial extraction procedures interceptive orthodontics, while we consider it to be a full-corrective modality. The correction of crossbites along with partial banded treatment was added to our definition of interceptive orthodontics.

(continued on page 20)

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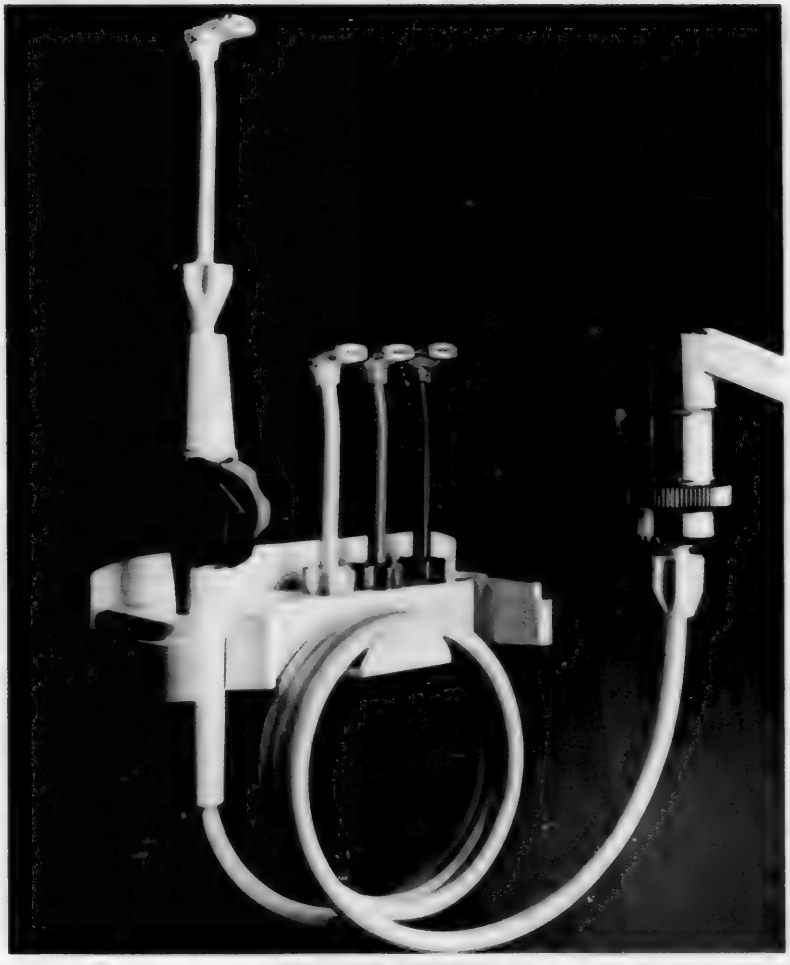

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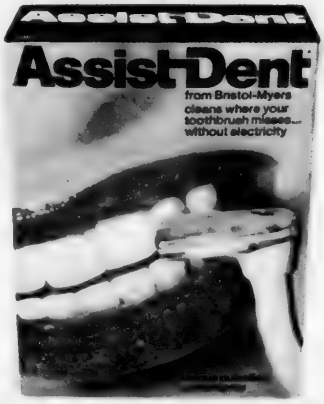

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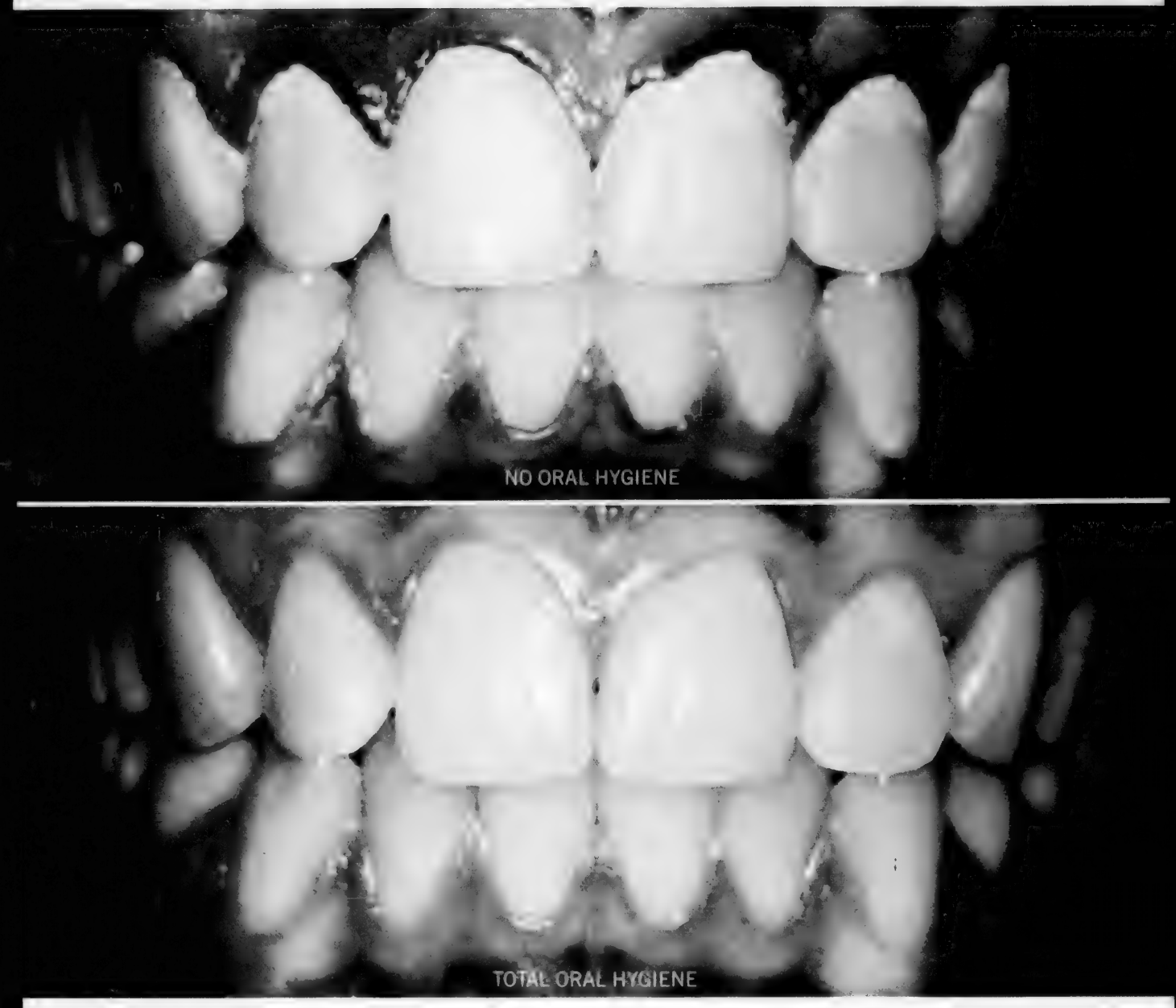

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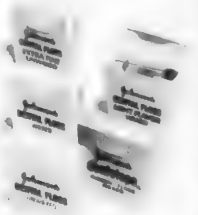

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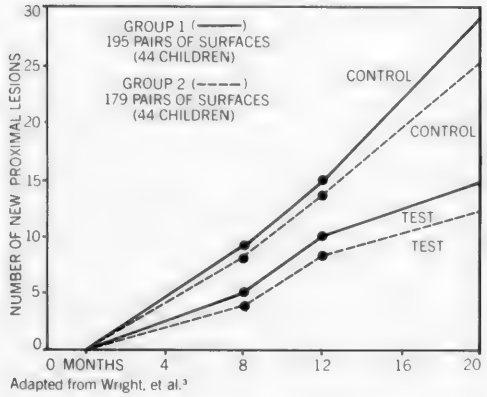
EFFECT OF FLOSSING ON INTERPROXIMAL DENTAL CARIES



Adapted from Wright, et al.[3]

As the chart illustrates, when the data from the two groups is combined, the flossed surfaces were found to have 53% fewer cavities than the control surfaces. The investigators noted the incidence of caries for both tests and controlled surfaces was almost identical when flossing was discontinued for 4 months.

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Regular flossing, by removing food particles and plaque, can improve gingival health and may also prevent the progression of periodontal disease. This was demonstrated in a recent study[4] of sixty patients with a high incidence of sulcular bleeding. The subjects were divided into either a control or a floss group. At the start of the study, a count was made of all bleeding sites. The test group was then instructed in the technique of flossing. After eight days, the original sites of bleeding were re-examined. As the graph below shows, when flossing was added to a program of oral hygiene, sulcular bleeding was significantly reduced.

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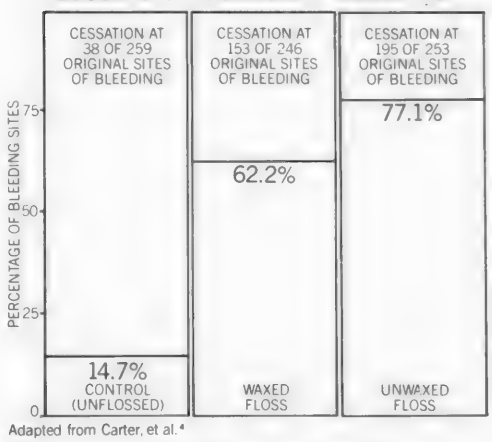

Adapted from Carter, et al.[4]

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Many patients are unaware or unconvinced of the value of flossing. So why not get them into the flossing habit. A strong recommendation and follow-up on your part will get them started on the path to better oral hygiene through flossing.

References: 1. Löe, H., et al.: *J. Periodontol.* 36:177, May-June 1965. 2. Wright, G.Z., et al.: *Caries Res. 10*, No. 5, 379-385 (1976). 3. Wright, G.Z., et al.: *J. Dent. Res.* 56: (Special Issue A), Abstr. 168 (1977) 4. Carter, H.G., et al.: *Va. Dent. J.* 52:18-32, 1975.

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(continued from page 14)

Aside from the diagnostic criteria definitions, there were other differences in the obtaining of the data. Burlington, Ontario was selected for research into preventive and interceptive orthodontics because it represented a typical suburban community as well as being in close proximity to the University of Toronto. Our population was derived from an urban as well as suburban community including the greater Philadelphia area with a radius of about 50 miles. We were essentially dealing with a demand population. This was expressed by the fact that approximately 98% of those examined were judged to need some form of orthodontic therapy. Although 33.5% of the Burlington serial control group of 312 patients were deemed not to require any orthodontic therapy, the two population samples cannot be directly compared. In the former, the patients are actively seeking treatment, while in the latter, treatment was delivered to a general population as required. Even with the advantage of their previous experiences, only 217 children out of 4200 were judged to profit from preventive and interceptive orthodontics, of which 156 proved successful. Ten discontinued therapy while 51 had to be transferred into the postgraduate orthodontic clinic for full therapy. The great advantage and strength of the Burlington Study lies in the 20 year follow-up of its patients. In our study, the patient population is still growing. The dentitions are still developing.

Table 1. Frequency of Dentitional Types for Patients Seen from October 1972 to February 1976

Group	Type of Dentition	N	%
1	Primary	81	2.0
2	Transitional	1364	32.4
3	Permanent	2755	65.6
Total		4200	100.0

Table 2. Frequency of Treatment for Patients with Primary and Transitional Dentitions (Groups 1 & 2)

Type of Treatment	N	%
Would not profit from treatment	66	4.6
Would profit from preventive and interceptive orthodontics	217	14.3
Would profit from full banded orthodontics	1172	81.1
Total	1455	100.0

Table 3. Frequency of Orthodontic Problems for Patients Receiving Preventive and Interceptive Orthodontic Treatment

Problem	N		%	
Alignment:	41		26.3	
Guidance of Eruption		10		6.4
Space Maintenance		13		8.3
Space Regaining & Closure		18		11.6
Sagittal:	42		26.9	
Class I Anterior Crossbite		15		9.6
Class II Anterior Protrusion		25		16.0
Other		2		1.3
Transverse:	40		25.6	
Bilateral Crossbite		15		9.6
Unilateral Crossbite		25		16.0
Vertical:	26		16.7	
Anterior Openbite		25		16.0
Posterior Openbite		1		.7
Other:	7		4.5	
Total	156		100.0	

The mechano-therapy was designed to be a one treatment approach, correcting a single occlusal mal-relationship within a period of 12 months. In preventive orthodontics, fixed soldered holding arches were inserted, while removable appliances accomplished the majority of treatment objectives for interceptive orthodontics. Retention became a function of the original problem. At the termination of treatment, the patient had to have an acceptable occlusion, one that possessed optimal occlusal and proximal contacts, one that was physiologic, that could function in health, and exhibited reasonable stability. In essence, no further treatment would be required. However, ideal occlusion as outlined by Andrew's[1] 6 keys to occlusion, might not be entirely fulfilled.

Certain trends and similarities have emerged. It is not surprising to find that preventive orthodontics and correction of crossbites are the most successful procedures in the 4–6 year old category, since there is not much else to be done in the primary dentition or early transitional dentition. Interestingly enough, only 81 (2%) of all the children evaluated were in the primary dentition, and 30 children were treated in the 4–6 age group. This extremely small percentage might be due to the benign nature of occlusal problems during the primary dentition or the parental lack of concern for the "baby teeth" that will soon be replaced by the permanent successors. The flouridated water supply in Philadelphia might also be a factor in explaining the reduced space maintenance as compared to the Burlington sample. Although Popovich reported a high incidence of habit consultations during the 3–6 year old period, we could not make that determination, since it would have entailed the registration of the patient for active therapy in order to have any consultations appear on the computer printout.

As the permanent teeth erupt, occlusal irregularities become more obvious to all concerned. Therefore, a greater number of patients with an increased number of noticeable dental problems are randomly seeking advice and treatment. This can be seen in the 7–9 year old category which benefitted the most from our procedures. The problems encountered are rather evenly distributed, which can only be explained by mathematics and not the predominance of any type of malocclusion.

When the early permanent dentition is approached in the 10–12 year group, existing problems become worse and do not lend themselves to preventive and interceptive orthodontic correction. The advent of the permanent dentition causes a marked decrease in any preventive or interceptive orthodontics since there is no longer anything to prevent or intercept. Full corrective orthodontics, whether in the late transitional or in the permanent dentition,

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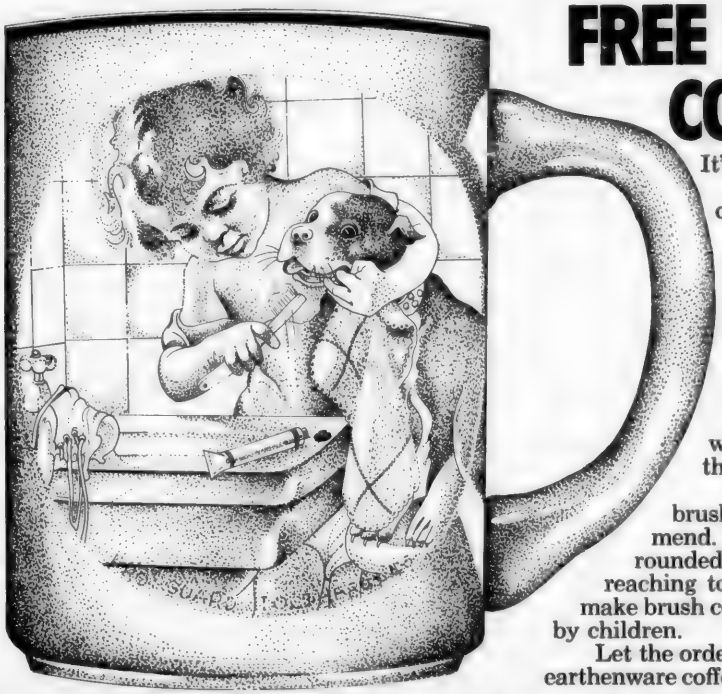

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Table 4. Frequency of Patients Receiving Preventive and Interceptive Orthodontics by Type of Problem and by Age

Type of Treatment	Age Distribution (years) 4–6	7–9	10–12	13–15	
Alignment:					
Guidance of Eruption	4	6			
Space Maintenance	5	6	2		
Space Regaining	2	9	6	1	
Sagittal:					
Class I Anterior Cross Bite		9	5	1	
Class I Anterior Protrusion	2	15	7	1	
Other		2			
Transverse:					
Unilateral Crossbite	4	16	5		
Bilateral Crossbite	6	7	2		
Vertical:					
Anterior Open Bite	4	18	3		
Posterior Open Bite		1			
Other:	3	4	—	—	
Total	30	93	30	3	156

is the preferred mode of orthodontic therapy.

Therefore it is imperative to employ preventive and interceptive orthodontic technics in the primary or transitional dentitions where the success rate can be as high as 12.1% while once the permanent dentition is realized the success rate drops to about 3.7%. This demand population can be compared with those people coming to an orthodontist's office for a consultation. For an orthodontist who evaluates 200 new patients in a year, this sample of 4200 patients represents 21 years of clinical judgment and practice. It becomes self evident that it is extremely important to see children at an early age, because if we are truly dealing with a preventive and interceptive orthodontic problem, then treatment should start as soon as possible. If we are merely dealing with "an early treatment problem," then "too much too soon" may be the real danger.

SUMMARY AND CONCLUSIONS

Some of the complex issues regarding the efficacy of preventive and interceptive orthodontics have been examined. In light of the historical background on this topic, operational definitions are offered to distinguish preventive and interceptive orthodontics from "early corrective" orthodontics. Methods for patient evaluation, selection and treatment as outlined are the results of a 3½ year descriptive clinical study.

Of the 1,445 patients in the primary and mixed dentition who presented for possible inclusion in the Preventive and Interceptive Orthodontic Clinic at the University of Pennsylvania School of Dental Medicine, approximately 1379 patients (97%) were indeed found to have developing malocclusions; however, only 217 patients (15.7%) were assessed as being able to profit from preventive and interceptive treatment. After treatment was completed and the patients were re-evaluated, it was determined that only 156 patients (11.0%) actually fulfilled the criteria for successful treatment. It is hoped, that these findings will be augmented by similar studies in the continual evaluation of preventive and interceptive orthodontic treatment.

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Fluoride Rinsing:

A School-Based Dental Preventive Program

Louis W. Ripa, D.D.S., M.S.,* Gary S. Leske, D.D.S., M.S., M.P.H.,†
and Warren G. Lowey, Ph.D.‡

School dental health programs can be categorized into those that primarily provide an educational component and those that include the children's active participation in procedures believed to provide a preventive benefit. Studies have shown, however, that while educational programs can successfully teach dental health principles, such programs have generally been unsuccessful in motivating children to practice acceptable dental behavior.[2,4,12–16]

Participation programs are of several types. Some school districts have dental facilities and provide dental hygienists who periodically clean the children's teeth. The cleaning may be performed with a non-active dental prophylaxis paste or one which contains fluoride as an active ingredient. Other school districts, in conjunction with local dental societies, have sponsored "brush-in" programs wherein groups of students are supervised as they brush their teeth with a topical fluoride agent.[10] Still other schools have adopted the "toothkeeper" program which emphasizes the teaching of proper toothbrushing and flossing technics.[6,9,16] Recently, programs in which children rinse with a fluoride solution under classroom supervision have been introduced in many schools. Rinsing programs are especially beneficial for those children who do not have access to optimal levels of waterborne fluoride, either because they are drinking fluoride-deficient water from a private source or because their community water supply is not naturally or artificially fluoridated. In 1975, the National Institute of Dental Research sponsored 17 demonstration programs throughout the United States and possessions in which school children rinse once a week using a 0.2% sodium fluoride (NaF) solution. Seventy-five to 80,000 children are enrolled in the programs which are anticipated to continue for a period of three years.

It is the purpose of this article to review some of the dental literature on fluoride rinsing, to describe the implementation of a weekly school rinsing program using a 0.2% NaF solution, and to list the advantages of such a program. The description is based upon a modification of the mouthrinsing demonstration program currently supervised by the authors in which approximately 4,600 children are enrolled. Readers should be aware, however, that demonstration programs at other sites are not necessarily following the same format but rather have developed their programs in accordance with the facilities and personnel available at their site.

LITERATURE REVIEW

The use of mouthrinses as a vehicle by which fluoride is applied in a self-administered preventive program was first proposed by Bibby and co-workers in 1946.[1] Since then, a number of different fluoride solutions and different rinsing frequencies have been tested. Thus, a 0.2% neutral NaF solution has been tested once a week[8] and once every two weeks,[18] a 0.05% neutral NaF solution has been tested once a day,[18] and different acidulated solutions of NaF have been tested once a day,[11] twice a day,[5] and once a week.[7] In almost all instances significant reductions in dental caries were achieved in children who participated in the programs for two years or longer. Indicative of the results were those of Horowitz and co-workers who reported a 16 and 44% caries reduction in first and fifth grade children respectively when rinsing was performed with a 0.2% neutral NaF solution once a week for two school years.[8] Recently, the Council on Dental Therapeutics of the American Dental Association reviewed the results of 19 clinical trials in which fluoride rinsing was evaluated for at least two years. Based upon this review, the Council accepted both neutral and acidulated fluoride solutions as "effective agents for use in reducing the incidence of dental decay."[3]

A METHOD OF IMPLEMENTATION OF A RINSING PROGRAM

A rinsing program can be administered from a school's health office and directed by the school nurse or school dental hygienist. The supervision of the actual rinsing can be done by the individual homeroom teachers.

The steps necessary to implement a school rinsing program include: (1) enrollment of the children in the program (2) preparation of the rinsing solution (3) training homeroom teachers to supervise the rinse sessions (4) initiation and continuation of classroom rinsing.

Enrollment of Children in the Rinsing Program

Parents must be informed of the rinse program prior to the enrollment of their children. Several methods may be utilized for publicizing the program. A letter of consent must be sent to each child's parent, and this letter may be designed to provide sufficient information about the program. Additionally, articles may be placed in the local newspapers or presentations may be scheduled before parent-teacher organizations.

The letters of consent can be prepared by the school's health office and then distributed by the homeroom teachers. In order to participate, each child must return the form signed by his or her parent or guardian. The letter of consent should include the following information: (1) A de-

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OLD VILLAGE CENTRAL SCHOOL DISTRICT

September 8, 1976

Dear Parent or Guardian:

The Old Village School District in cooperation with the County Health Department plans to conduct a community caries prevention program in your child's elementary school. The project has been endorsed by the County Dental Society.

Each child who participates in the program will rinse with a 0.2% neutral sodium fluoride mouthrinse once each week. The procedure is simple, safe and will require very little time in the classroom. Once a week the rinse is swished in the mouth for one minute and then returned to a paper cup for proper disposing. Studies conducted with this fluoride rinse have shown that the number of newly decayed teeth has been reduced by as much as 45 percent. There are no known risks attendant with this program and the 0.2% neutral sodium fluoride is safe even if your child should accidently swallow the rinse. The program will be supervised in all classes by the classroom teachers.

Participation in the mouthrinse program is voluntary and there is no cost to you to allow your child to participate. This program, however, will not take the place of regular dental check-ups, treatment by your dentist or proper home care. Any questions concerning the mouthrinse procedures will be answered by _____ at telephone number 123-4567.
Rinse Coordinator

Sincerely yours,

_____
President, County Dental Society

_____
Rinse Coordinator

_____
School Principal

----------Please Tear and Return----------

CONSENT FORM

For the School Mouthrinse Program

Please fill out and return to the teacher by September 10, 1976. Please print the information and sign your name. Thank you.

Homeroom Teacher _____ Grade _____

To the Principal:

I do give my permission to have _____ participate in the school
(child's first and last name)
mouthrinse program. I understand that my child may be withdrawn from this program at anytime.

I do not give permission to have _____ participate in the school
(child's first and last name)
mouthrinse program.

Date:_____ Signed: _____ Telephone: _____
(Parent or Guardian)

FIG. 1. Sample letter of consent.

scription of the rinsing procedure and the purpose of the program. (2) A description of any attendant risks or discomforts reasonably to be expected. (3) A description of any benefits reasonably to be expected. (4) An offer to answer any inquiries concerning the procedure. (5) A statement that the parent is free to withdraw consent and the child is free to discontinue participation in the program at any time. The text of a sample letter of consent is reproduced in Figure 1. Notice that the school letterhead is used and the signatures of the program coordinator (school nurse or hygienist) and school principal are included. Since parents will frequently seek the advice of their dentist before agreeing to have their children participate, the endorsement of the local dental society is usually sought when contemplating such a project. Thus, a statement that the local dental society supports the program, together with the signature of the dental society president, may appropriately appear on the consent form. The form, which must be signed by a parent or guardian, should clearly indicate whether a child *will* or *will not* participate. There should also be a space for the parents to indicate their child's grade and homeroom teacher so that participating children can be easily located within the school. From the completed forms a master list is prepared which identifies the participating children by their homerooms.

A second distribution of the consent forms is usually necessary. Figure 2 shows the response of parents following a first and second distribution of consent forms in a school-based rinsing program being conducted by the authors. In this program, participation was increased by 5.4% (320 additional children) as a result of a second distribution to families who did not initially respond.

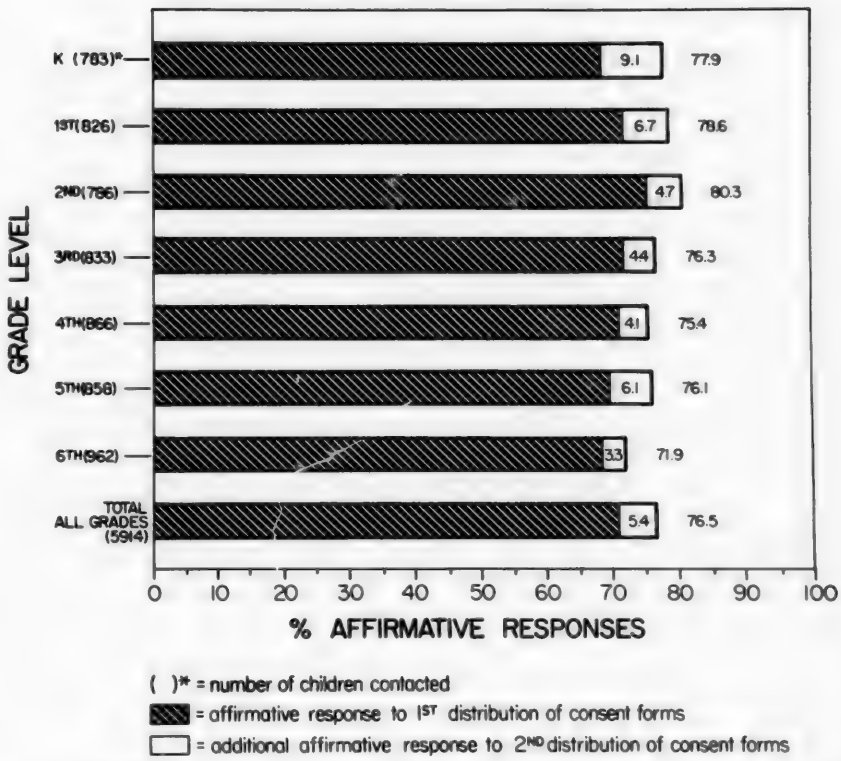

FIG. 2. Response rate to letters of consent inviting participation in a school-based fluoride rinsing program.

Preparation of the Rinsing Solution

The preparation of the fluoride rinse is the responsibility of the school nurse or dental hygienist.* A 0.2% NaF solution is prepared by mixing 3 g NaF with 1500 ml tap water. Thus the 10 ml that each child uses for weekly rinsing contains 9 mg F. Commercially available premeasured packets of NaF powder may be added to a premarked container (Fig. 3). The containers are closed and shaken for 10 to 15 seconds to dissolve all of the powder. The caps are then replaced with pumps calibrated by the manufacturer to deliver 10 ml (2 teaspoonsful). Generally, a fresh solution should be prepared each week.

Training Homeroom Teachers as Rinse Supervisors

Prior to the actual rinsing it is recommended that two practice sessions, using tap water as a placebo rinse, be held. During these sessions the school nurse or hygienist instructs the classroom teachers and the enrolled children in the proper rinsing technic.

The prepared rinse solution can be dispensed into paper cups and taken on trays and carts to the individual classrooms, or a dispensing bottle can be brought to each classroom (Fig. 4A) and the cups filled there. In either case, the pump must be primed first by pushing the plunger down several times and the initial solution discarded.

In each classroom the teacher calls the names of the participating children. Each child receives a disposable cup containing 10 ml of the NaF solution and a paper napkin (Fig. 4B). If participation is being monitored, the children's names are checked on a list kept in each classroom. Most class-

FIG. 3. Preparation of a 0.2% NaF solution is easily accomplished utilizing premarked containers and premeasured packets of NaF. Samples of one commercial supplier are illustrated. Note that the containers are marked at the 1000 and 1500 ml. level. The former requires 2 g NaF, the latter 3 g.

* Depending upon the availability of personnel, other individuals may be delegated the responsibility of mixing the solution.

FIG. 4A. The rinse solution is brought to each classroom. (Courtesy of Pat Wiegand, Photographer, Three Village Herald, Stony Brook, N.Y.)

FIG. 4B. Participating children each receive a paper napkin and 10 ml. of the solution in a paper cup. (Courtesy of Pat Wiegand, Photographer, Three Village Herald, Stony Brook, N.Y.)

rooms contain a wall clock with a sweep second hand. The teacher times the rinse for 60 seconds (Fig. 4C) and reminds the children to swish the solution and to use cheek pressure to force the fluid around and between the teeth. The teacher also reminds the children not to swallow the solution. After 60 seconds the children expectorate into the paper cups, wipe their mouths with the napkins, and place the napkins in the cups to soak-up the solution. The teacher or a child then collects the cups and napkins in a disposable bag (Fig. 4D) which is tied and deposited in a wastebasket.

Initiation and Continuation of Classroom Rinsing

Initiation of the actual rinsing sessions follows the same format developed during the practice, or placebo, sessions. The mixed fluoride solution is brought to the individual classrooms and dispensed to the participating children. Rinsing is timed for 60 seconds and then all refuse is collected and discarded. If the mixed solution was brought in bottles, the bottles are collected and stored centrally until the next week.

Because many children do not stay in their homeroom all day, it is best that rinsing be done early in the morning. This approach causes the least disruption of the day's other classroom activities. The same classrooms should rinse on the same day each week. Generally, Monday should not be designated as a rinse day since many national holidays are now celebrated on Mondays and the schools are closed.

ADVANTAGES OF FLUORIDE RINSING

A program in which children rinse on a scheduled basis in the classroom has several advantages.

(1) *The efficacy of the rinsing technic in reducing dental caries has been demonstrated in numerous clinical trials*. The caries reductions obtained in the fluoride rinsing studies that were reviewed by the Council on Dental Therapeutics of the American Dental Association ranged from 11 to 80%.[3] While the concentration of fluoride, the frequency of application, and the type of fluoride varied between the different studies, the combined average caries reduction was 32%.

(2) *Few materials are required and the cost is low*. The major equipment for a rinsing program includes a locked cabinet to store the fluoride supplies and a mobile dispensing cart for each school. The rinsing supplies include calibrated pumps and containers, paper napkins and cups, disposal bags and ties, and pre-mixed packets of sodium fluoride. One commercial supplier* currently estimates the supplies to cost 45¢ per child to rinse once a week for a school year (36 weeks). Recently, another commercial source† has indicated that a *premixed* flavored fluoride solution (POINT-TWO®) can be provided with some of the other rinse supplies at a competitive price. The additional costs of the program are for the printing of letters of consent and for other office-related expenses.

(3) *Little time is involved per session so that frequent treatments can be accomplished with minimum disruption of classroom time*. Table 1 presents the classroom time utilized for rinsing in the program directed by the authors. Average rinsing times are presented for a typical month of the program. The average time was 5.0 minutes per classroom rinse session, with a range of 1.5 to 16 minutes.

(4) *Non-dental personnel with minimal training can easily supervise the procedure*. The program uses classroom teachers who, with minimal training, act as rinse supervisors. Additionally, the program is administered by the school health office where, if a dental hygienist is not available, it may be coordinated and directed by the school nurse.

(5) *The technic of administration is easy*. The rinse procedure is one

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† Hoyt Laboratories, Needham, Mass.

FIG. 4C. The children rinse for 60 seconds and then expectorate back into the paper cups. (Courtesy of Pat Wiegand, Photographer, Three Village Herald, Stony Brook, N.Y.)

FIG. 4D. Cups and napkins are collected in a disposable trash bag and are discarded. (Courtesy of Pat Wiegand, Photographer, Three Village Herald, Stony Brook, N.Y.)

that most children can perform and, in fact, have usually performed in other circumstances at home. Thus, participation can begin in the kindergarten and extend to the highest grade level in the school. The only contraindication to an individual participating might occur in the lower grades where an occasional child might habitually swallow, rather than expectorate, the rinse.

SUMMARY

Dental health programs in the schools are not new. Such programs may be primarily educational or may actively involve the children in a dental preventive technic. Recently, programs in which children periodically rinse with a fluoride solution under supervision in the classroom have been introduced. Fluoride-rinsing programs have several advantages: they are easy to establish, do not require dental personnel, are relatively inexpensive, and only minimally infringe upon normal classroom activity. This article describes the implementation of a school-based rinsing program in which children rinse once a week with a 0.2% NaF solution. The program that has been described may be directed by the school nurse or, if available, the school dental hygienist; the classroom supervision of the actual rinse procedure is supervised by the homeroom teachers.

Table 1. Classroom Time Required for a Single Rinsing Session

Grade Level	No. of Classrooms	Average Time Per Rinse Session* (minutes)	Range (minutes)
K	35	5.7	3 –13
1	38	4.6	2 –10
2	36	5.1	3 –12
3	36	4.7	2.5– 9
4	34	5.0	1.5–10
5	33	5.3	1.5–15
6	37	5.0	2 –16
All Grades	249	5.0	1.5–16

* Based upon three or four rinse sessions for each classroom.

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Arch Length

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"Good check-up, Mrs. Parent," said Dr. Molar. "Johnny didn't have any cavities this time."

"I'm delighted to hear that, Dr. Molar," Mrs. Parent replied. "But tell me, why do Johnny's new front teeth seem so crooked? They're all jumbled up. His baby teeth were so nice and white and straight, and these new teeth seem so large. I'm really very concerned."

Dr. Molar looked again at Johnny's mouth and said, "They do seem large and crowded, but your son is only seven. His jaws still have a lot of growing to do. Perhaps they will grow enough to support his teeth."

"Perhaps," that vague and unscientific term. Johnny presented with an obvious problem, anterior crowding, which is indicative of an overall arch length deficiency. There is no "perhaps" about it. Johnny either has or does not have an arch length deficiency. There are means available to accurately make this determination.

TYPES OF ARCH LENGTH DISCREPANCY

Three types of arch length discrepancies exist.[11] The first and by far the most common is an excess of tooth material in relation to the amount of basal bone that exists to support the teeth, ultimately resulting in crowding of the dentition.

The patient who has been totally edentulous for twenty years has nothing left but basal bone. This basal bone, or apical base,[13] is genetically determined and remains unchanged whether teeth are present or not. The alveolar bone, the denture bearing ridge, exists to support teeth. Once the permanent teeth are lost, the alveolar bone is also lost. In the arch length deficiency, the basal bone or apical base is insufficient to carry all of the teeth and their concomitant alveolar bone.

The second problem is the exact reverse of the arch length deficiency. In this case, we are presented with an arch length excess. The amount of tooth material and its associated alveolar bone is small in comparison with the basal bone. The overall result is spacing between the teeth.

The third problem is one of a tooth-size to tooth-size discrepancy, the teeth in the maxillary arch not matching those in the mandibular arch, making normal occlusion unattainable.

GENETIC DRIFT

From our prehistoric forebearers to man as we know him today, the evolutionary trend has been one of reduction of facial dimensions.[24] Genetic drift has allowed for diminution in both the skeletal framework of the face and the dentition. But man's face is getting smaller at a greater rate than his teeth. The overall result is one of an increasing tendancy toward dental crowding.[18]

For stone age man, arch length discrepancy was rarely a problem.[6,7] Proximal attrition and occlusal attrition to below the level of the contact points[8] allowed eruption of the full adult dentition into uncrowded positions. With civilization and refinement of food products, modern man has lost attrition as a positive factor in the eruption of his dentition.[19]

Normal development of the dental arches toward the goal of a functional occlusion, being thus challenged by genetic trends, is often not achieved. The dentist, whose task it is to monitor this process, is faced with a complicated diagnostic and treatment situation. He must determine whether there will be sufficient room for all of the permanent teeth to erupt into normal occlusion. If not, he must then determine the best course of treatment for his patient, which may include referral to an orthodontist or pedodontist for growth and development supervision.

EXTENT OF THE PROBLEM

Salzmann[35] has pointed out that "Ideal occlusion is a hypothetical formula which does not, and cannot, exist in man. Ideal tooth form and ideal occlusion

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necessitates an unblemished heredity, an optimum favorable environment and a developmental history devoid of any accident, diseases or occurrence which would modify the ideal inherent growth pattern."

It has been determined[16] that 50 to 60 per cent of the children in the 10 to 19 year age group have some degrees of malocclusion. Of these, more than half[3] have a moderately severe to handicapping malocclusion.

The inter-relationship of abnormalities comprising a malocclusion, both dental and skeletal, are extremely complex. Arch length discrepancies are only one of the many characteristics of a malocclusion.[1] In addition to arch length (alignment) problems, there may be deviations in the sagittal, transverse and/or vertical parameters, as well as deviation in the soft tissue drape overlying the dental and skeletal systems. The dentist must be able to recognize problems developing in any of these areas, and be prepared to deal with these problems or refer them for treatment.

DEVELOPMENT OF NORMAL OCCLUSION

Dental development begins at 4½ to 5 months *in utero*,[36] starting with the central incisors. During the first three years of life, growth of the cranium is rapid, but even more rapid is growth of the face as it swings itself downward and forward, out from under the cranial base.[11,12]

The deciduous teeth begin eruption about the sixth month, with all 20 of them fully in place by the third birthday.[37] Measuring from the distal of the second deciduous molar on one side, bucco-lingually through the contact areas in the posterior and along the incisal edges in the anterior, to the distal of the second deciduous molar on the other side, gives the available arch length. From the third year of life to eruption of the full permanent dentition, there is net decrease in the arch length available.[28,38,39]

Given a normal Class I skeletal relationship, two distinct dental patterns are considered normal in deciduous dentition. The first of these presents with congenital "primate spaces"[4] between the maxillary deciduous laterals and canines, and the mandibular deciduous canines and first molars. The flush terminal plane relationship of the second deciduous molars is altered to a full Class I relationship at eruption of the first permanent molars. This "early mesial shift"[5] occurs *via* closure of the primate space, allowing the first permanent molars to erupt into a full Class I relationship.

In the second most common dental pattern, primate spaces are absent.[4] Due to the flush terminal plane relationship, the first permanent molars are forced to erupt into an end-on, cusp-tip to cusp-tip relationship. "Late mesial shift"[5] occurs at eruption of the permanent canines and premolars, allowing the mandibular molar to drift mesially a greater distance than the maxillary molar.

The space provided for this late mesial shift is called the "leeway space" of Nance.[31] The mandibular molar has an average leeway space of 1.7 mm on each side, whereas the maxillary molar has but 0.9 mm per side. Thus the mandibular molar can move forward in the arch a greater distance than the maxillary molar, resulting in the late mesial shift from an end-on to full Class I first permanent molar relationship.

At eruption of the mandibular incisors, there is an increase in intercanine distance, due to lateral pressure from the mandibular incisors. In turn, the mandibular deciduous canines being forced laterally place pressure on the maxillary deciduous canines, forcing them laterally. This "secondary spacing"[15] creates more room for eruption of the maxillary permanent lateral incisors.

Once erupted, the mandibular permanent incisors may show some transient crowding. Up to 2 mm of crowding in this area will be reduced completely by age 8 in boys, and reduced to 1 mm by the same age in girls.[26]

On the other hand, spacing exists in the maxillary arch, most noticeably between the central incisors. This "ugly duckling"[11] stage lasts until the maxillary canines erupt, creating sufficient pressure to upright the incisors and close, in the absence of a hypertrophied maxillary labial frenum, the midline diastema.

Canines and premolars erupt in predictable order[22] with variations occurring according to age, sex, and genetic pattern. Girls have on the average 28 of their 32 permanent teeth fully erupted at an earlier age than boys. There are some differences in the eruption order of the succedaneous teeth, the most noticeable being that girls tend to have mandibular permanent canines erupted

(continued on page 34)

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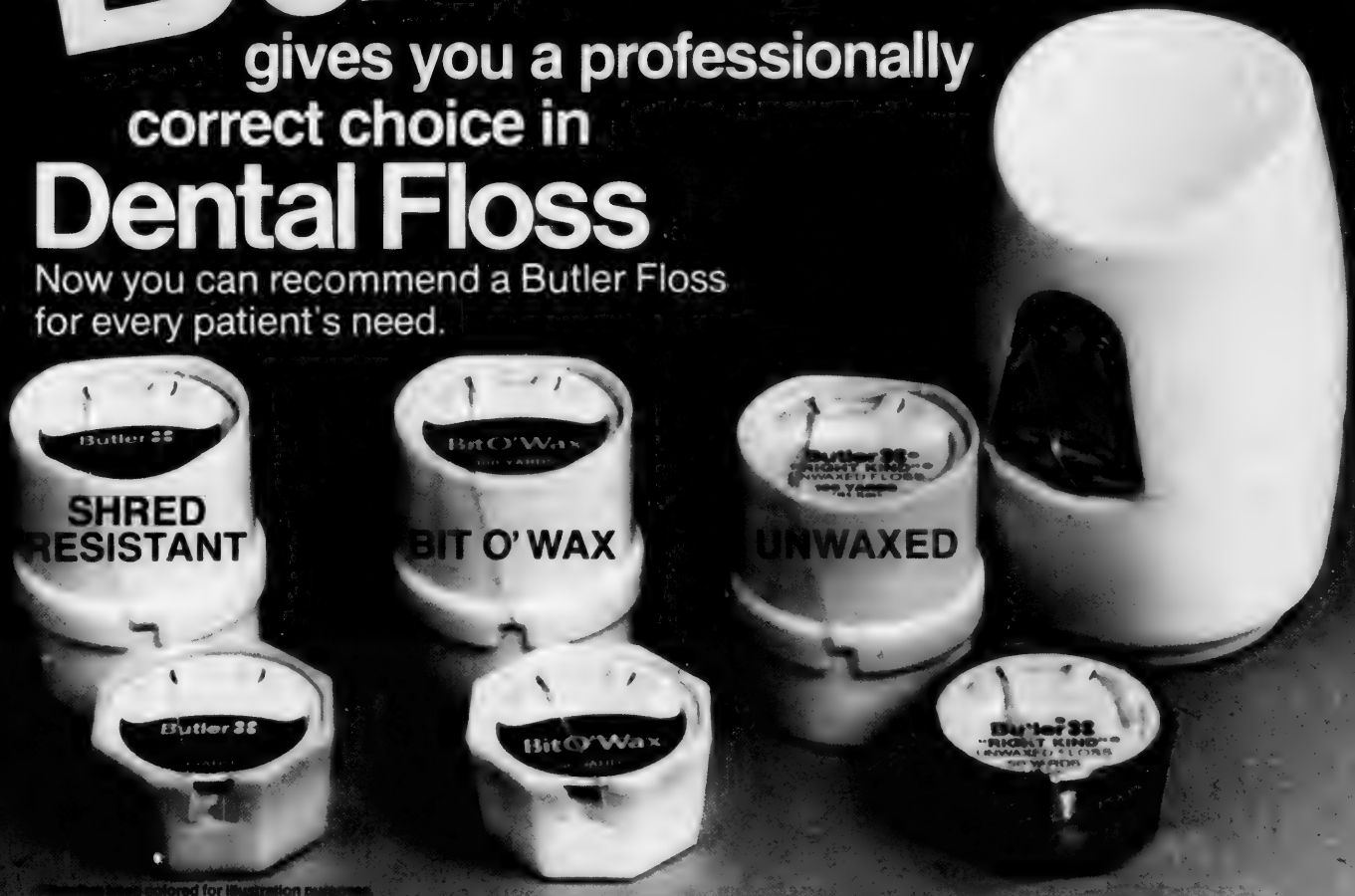

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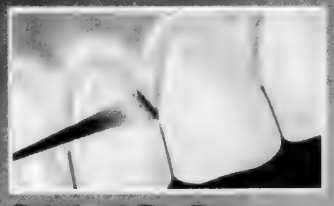

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(continued from page 32)
before eruption of the first premolars, where boys will erupt both at about the same time. In both girls and boys, the maxillary canines are the last maxillary succedaneous teeth to erupt.

Once erupted, all permanent teeth assume a position of equilibrium,[43] supported by the musculature, over basal bone. With continued growth, the incisors tend to become more upright, and the anterior overbite deepens with maturity.[9]

Despite the transient increase in arch length gained at eruption of the permanent incisors, incisor uprighting and molar movement to use the primate and leeway spaces result in an overall shortening of arch length.[27] It cannot be anticipated, given the weight of scientific evidence to the contrary, that a child with severe dental crowding at age 7 will have anything other than severe dental crowding at age 12.

CAUSES OF ARCH LENGTH DISCREPANCY

In his fine series of articles on Serial Extraction, Dale[15] listed the signs of a true hereditary arch length deficiency. With modification, they are as follows:

1. Premature exfoliation of one or more of the primary cuspids. If only one is lost, the mandibular incisors usually tip laterally toward that space.

2. Crescent shaped resorbtion on the mesial aspect of one or more deciduous canine roots.

3. Lingual displacement of one or both mandibular lateral incisors. If only one is displaced, the mandibular midline will deviate to that side.

4. Labially locked mandibular incisor, usually one of the central incisors, with severe gingival clefting or recession on the labial surface. In cases such as this, repositioning of the incisor over basal bone creates better gingival and bony architecture. It is therefore advisable to postpone gingival grafting procedures until after the tooth has been repositioned.

5. Crowding of the unerupted canines, causing them to bulge to the labial. If allowed to erupt in these labial positions, the result may be a compromise in width of the zone of attached gingiva on the labial surface of these teeth.

6. Splaying of the maxillary and/or mandibular incisors due to the crowded positions of the canines.

7. Ectopic mesial eruption of the maxillary first permanent molar, causing early exfoliation of the second deciduous molar. Failure to treat this condition will result in additional mesial migration of the maxillary first permanent molar, causing eventual impaction of the maxillary second premolar and severe tipping and rotation of the first permanent molar.

8. Vertical palisading of the maxillary permanent first, second and third molars in the tuberosity area.

9. Impaction of the mandibular permanent second molar.

10. Bimaxillary protrusion. Dento-alveolar protrusion in the anterior area, superimposed on a Class I skeletal pattern. This is a crowed dentition in which the teeth do not become crooked, but instead lean forward, cantilevering off their basal bone support.

Not all arch length deficiencies are caused by genetic input. Most of the other causes are neglect on the part of parents, or mismanagement of the part of the dentist. They include:

1. Premature loss of deciduous teeth without benefit of space maintenance. The result is mesial migration of posterior teeth and distal migration of anterior teeth,[32] resulting in additional arch length reduction.

2. Untreated interproximal caries in deciduous teeth. The deciduous teeth drift into each other, flattening the contact areas, reducing arch length.

3. Uneven resorbtion of primary teeth, causing over-retention of the primary teeth and ectopic eruption of the permanent teeth.[23] It has been determined that a permanent tooth will erupt when the root is approximately two-thirds formed. Extraction of the deciduous predecessor, prior to this stage in permanent tooth formation, in the absence of alveolar bone loss due to periapical infection, will not enhance the rate of eruption of the permanent tooth,[17] but will permit a more normal path of eruption.

4. Abberation in the eruptive pattern of the permanent teeth, as in the early extraction of the deciduous canines preventing the formation of secondary spacing in the maxillary lateral incisor areas.

5. Contracted or asymmetrical dental arches. These may be caused by any of a number of abberant functions, such as thumb-sucking, mouth breathing, occlusal interference, *etc*.

6. An anomalous tooth or

teeth, such as overly-large second premolars.

7. Oversized crowns on fractured anterior teeth. There is a strong tendancy, during the ugly duckling stage, for the crowns that are made to be oversized, taking up what is at that time a normal maxillary midline diastema.

8. Overcontoured posterior restorations of interproximal lesions, occluding a portion of the space required for eruption of the succedaneous teeth.

9. Over-retained deciduous second molars in the patient with congenitally missing second premolars.[41]

The causes of arch length excess are, for the most part, the reverse of those for arch length deficiency. It is very rare that a patient presents with even spaces between all of his permanent teeth. More often spacing is caused by: (1) One or more teeth being anomalously small, as peg-shaped laterals. (2) Thick, low maxillary frenum attachment, causing a midline diastema. It must be noted that unless plans are made to close the diastema prior to healing of the frenectomy, scar tissue may form in the operated site, preventing the teeth from being brought together. (3) Abberant muscle function, as a tongue thrust, pushing the incisors forward and causing them to flare. (4) Other habits, such as finger or thumb sucking, causing flaring of the incisors. (5) Loss of posterior teeth with posterior bite collapse and resultant anterior flaring.

The third type of arch length discrepancy is neither deficiency nor excess, but is due to a malrelationship between the sizes of the maxillary and mandibular teeth.[10] The mean value for the relationship between the maxillary 6 anterior teeth and mandibular 6 anterior teeth is that the maxillary 6 anterior teeth are about 27 per cent larger than the mandibular. This creates a normal overbite-overjet relationship in the anterior.

If the maxillary anterior teeth are less than 27 per cent larger than the mandibular, as in the case of peg-shaped laterals, the overbite will be reduced toward zero unless spaces are permitted to exist in the maxillary anterior region.

If the maxillary anterior teeth are more than 27 per cent larger than the mandibular, as in the unfortunate extraction of a labially locked mandibular incisor with severe gingival recession, the overbite will deepen considerably. Unless the maxillary teeth are proportional in size to the mandibular teeth, they will not occlude normally.

MEASUREMENT OF ARCH LENGTH

Determination of arch length discrepancy involves measuring the amount of arch length available, and subtracting from that the amount of arch length required.

Nance[31] suggested the use of a soft brass wire to measure arch length available. By bending the wire, usually .020 in diameter, to conform to the arch form presented by that patient (a form that relates to the underlying basal bone contour), the wire can be laid across the incisal edges of the anterior teeth and over the contact points of the posterior teeth. The wire is then marked at the distal of the second deciduous molar and straightened. The distance between the two marks is the arch length available.

Musich and Ackerman[30] have suggested the use of an instrument called the catenometer to measure arch length available. They found the catenary method considerably more reliable than the brass wire method for making this measurement. The instrument gives a direct reading of the measurement on a Boley gauge.

Other authors[21,33] have suggested the use of calipers or dividers to measure segments of the arch, then adding the segments together to arrive at the measurement for arch length available.

To evaluate arch length required, the mesio-distal widths of all teeth anterior to the first permanent molars must be added together. In the fully erupted permanent dentition, these measurements can be taken directly from the study models.

In the mixed dentition, there are two basic methods available for determining the widths of the unerupted permanent teeth. The first of these is direct measurement of the unerupted teeth on radiographs.[31] It must be noted that to minimize distortion and enlargement, parallel films taken with the long cone technique are preferred. If bisecting angle—short cone films are used, a correction factor must be used to account for radiographic magnification. The use of panoramic x-rays for taking these measurements is strongly contraindicated,[14,34] again due to distortion of the radiographic image.

The second method is an in-

direct prediction. The incisors are measured, and their widths are fed into prediction table. The table in turn gives the estimated widths of the unerupted permanent teeth.[29,40]

ARCH LENGTH DISCREPANCY

Arch length available minus arch length required equals arch length discrepancy (ALA − ALR = ALD). This resultant sum is the basic information from which arch length is considered. The following adjustments must be considered: (1) Transient increase in arch length available at eruption of the permanent incisor-canine complex. (2) Decrease in arch length as leeway space is used. (3) Uprighting mesially tipped mandibular molars. (4) Relocating the lower incisor over apical base. For every 2.5° the mandibular incisors are tipped to the lingual 1 mm of arch of arch length is required to accommodate them. (5) Flattening the Curve of Speé is required to allow all teeth to properly contact each other. A flat occulsal plane is most receptive to normal occlusion.[2] Approximately three quarters of a millimeter of arch length is required to accommodate each millimeter of bilateral flattening of the curve.

The mandibular arch is the contained arch. It is less amenable to treatment than the maxillary arch. If the mandibular arch length deficiency (ALD), as modified by a variety of factors, is greater than −4 mm, extraction of permanent teeth will probably be necessary. To expand or "develop" the arch beyond this point is to cantilever the teeth off of their basal bone support. This invites either collapse of the arch with recurrence of crowding,[42] or stress and eventual breakdown of the investing and supporting structures of the teeth.[20]

Example

Let's take a look at Johnny, Mrs. Parent's 7-year old with the crowded teeth. Measuring his arch with a catenometer, it was found that Johnny had a mandibular arch length available (ALA) of 63.4 mm. Direct measurement with a Boley gauge of the erupted incisors on the models, and of the canines and premolars on parallel-long cone periapical films, revealed a total mesio-distal measurement of 67.9 mm of arch length required (ALR). Feeding these numbers into the formula ALA − ALR = ALD, we find that Johnny has an arch length deficiency of −4.5 mm. Clearly, room for eruption of the permanent dentition into good alignment, well supported over basal bone, simply does not exist.

But what of the contention that he might grow out of this problem? As his permanent canines erupt, approximately 1 mm of arch length will be gained. The mandibular molars are upright, so no space can be gained there. There will be space loss, approximately 3.5 mm, as leeway space is used. The mandibular incisors are somewhat flared, about 10°, and require 4 mm of arch length to be uprighted. The Curve of Speé was relatively flat, so no alignment was necessary there. With these factors in mind, the −4.5 mm ALD must be modified by adding the plus factors and subtracting the negative. The equation becomes, in this case, − 4.5 mm (ALD) + 1 mm (canine eruption) −3.5 mm (leeway space) − 4 mm (upright $\bar{1}$) = − 8 mm total arch length deficiency anticipated at eruption of the full adult dentition.

This is the rule, to which there is almost no exception. Arch length shows an overall decrease during the transition from the deciduous to the permanent dentition,[25] and continues to do so throughout life.

SUMMARY

From an evolutionary standpoint, our dental arches are progressively getting smaller at a faster rate than our teeth. The overall result is a constantly increasing incidence of dental crowding.

Arch length deficiency is a problem that is recognizable as early as the eruption of the permanent incisors. Accurate means are available for assessing the severity of arch length discrepancy.

If such a discrepancy does exist, it should be evaluated in relation to the skeletal and soft tissue framework as to management of the problem.

The development of a normal full adult dentition is a complex process. Availability of arch length to support the intact dentition is a prime requisite, requiring total understanding of the growth and development process for proper supervision.

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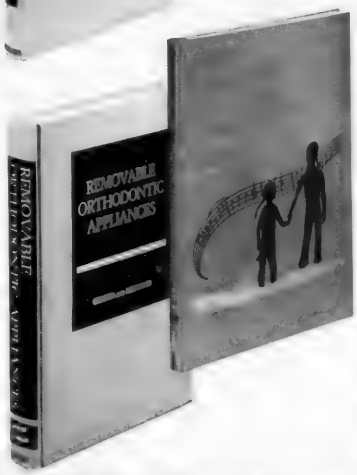

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Tooth Eruption and Ankylosis

Irving W. Eichenbaum, D.D.S.*

Dento-facial abnormalities are incipient in many of the children seen in the dental office today. It is understandable that these malocclusions may occur more or less readily when one pauses to consider the vast variety of facial forces (Fig. 1) to which the child is heir, and that the result of all these applied forces is what we term occlusion.[4] On the one hand are forces which will tend to produce a masticatory apparatus both pleasing and esthetic and on the other perhaps those very same forces, improperly applied or in an undesirable sequence, will produce a less than desirable result.

Klein states, "It is generally accepted that dental and facial deformities may be the result of many etiological factors, such as hereditary factors, environmental factors, nutritional factors, endocrine dysfunction, premature loss or prolonged retention of primary teeth, malformed or supernumerary teeth (Fig. 2), loss of permanent teeth, pathological entities, as well as abnormal pressure habits, all of which may function singly or be superimposed upon each other."[5]

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Clinical observation will confirm that, on occasion, proper and normal growth patterns may negate each other when extraneous factors are involved in the process of maturation and eruption. While growth, development and eruption of the teeth is generally acepted as a routine process and a usual occurrence, the forces acting on the developing dentition are many and varied and can be detrimental or beneficial and thus frequently the outcome is dependent on some balance of natural impetus.

This impetus for change, from the primary to the permanent dentition, proceeds with great rhythm and specificity, guided by some hidden genetic clock, and responding to the needs of the dento-facial complex. This rhythmic pattern, if disturbed is indicative of some abnormality, general or local, and the phenomena must be evaluated in these terms. Many physiologic and genetic considerations may influence the embryonic tooth and impair or impede the eruptive process as a companion syndrome. However, should development proceed within normal limits eruption can be anticipated with some certainty. It is the purpose of this paper to discuss one specific eruptive aberration; that of tooth ankylosis.

"Early in embryonic life, the oral epithelium thickens locally and dips into the mesenchyme and there are formed successively, the dental lamina, deciduous tooth buds and the anlage for the permanent teeth, usually in overlapping stages. These epithelial derivatives grow in a direction away from the oral cavity. Once the tooth is sufficiently formed, a new movement commences in the opposite or coronal direction. This movement is tooth eruption. Although tooth eruption in the past has been defined as the breaking out or emergence into the oral cavity, the more modern definition considers the actual emergence as merely an important incident in the larger process. This larger process of eruption includes the entire interval from the beginning of this coronal movement to the time the tooth is lost or death ensues. It continues even after the teeth reach their antagonists at the occlusal level, to compensate for the resulting abrasion. It is manifest also in growth beyond the occlusal level when the antagonist is lost. It is therefore quite apparent that constant coronal movement in some degree is characteristic of all normal teeth, *i.e.* normal teeth are continuously erupting."[1] Within the interpretation of this statement any tooth which loses this potential can be classified as unerupted or impacted and contains profound implications for

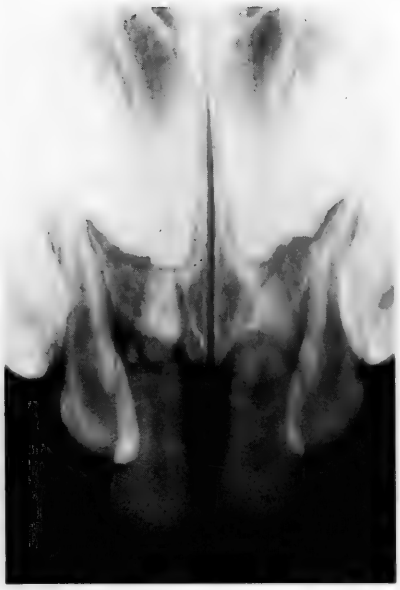

Fig. 1. This child had a severe blow to the face at age 16 months. In addition to primary root fracture, dilaceration appears to be present at the incisal edge of the right permanent central. Observation of the resorption of these root fragments is important. Unresorbed they may act to retard or prevent eruption of their succeeding centrals; infected they may act in a similar manner. The patient was 3 years of age at the time of the radiograph.

the integrity of the developing mechanism and the establishment of an acceptable, functioning and esthetic dentition.

IMPACTED TEETH

Impaction is an interference with the normal process of tooth eruption thus not permitting the dental member to assume a position in the dental arch. This phenomena may confine itself to a single tooth or may occur in multiple areas in the dentofacial complex. The inciting factors in impaction are many and varied and the consequences are often permanent. Some of the more frequent clinical findings in impactions include: (1) trauma

Fig. 2. Periapical views of supernumerary teeth should be supplemented with occlusal radiographs to place the entire anterior maxilla in proper perspective.

and infections; (2) supernumerary teeth; (3) over-retained primary teeth or root fragments; (4) ankylosed teeth.

TRAUMA AND INFECTION

Children are involved in many accidents wherein a blow to the anterior maxilla or mandible is received and pathology is a (Figs. 4A and B) frequent companion to the situation. Unless treated as soon as identified, this situation can terminate in a destructive eruptive pattern. The fragile, developing permanent central incisors can be diverted from their usual path and a most bizarre picture may evolve. It is not unusual to find a primary incisor and a fully erupted permanent incisor side by side or to demonstrate the incisal edges of these permanent teeth erupting high in the mucobaccal fold in near horizontal plane (Fig. 3).

Fig. 3. This eruptive pattern should be viewed with much suspicion. Primary incisor is firm and child is eight years of age. Ankylosis and/or trauma may be involved.

SUPERNUMERARY TEETH

One of the prime etiologic[4] factors in the lack of eruption in the anterior maxillary region is supernumerary teeth. These mesiodens are often quite small, lingually placed and appear incapable of retarding the eruptive forces of a central or lateral incisor. Once careful radiographic examination eliminates all other factors, the removal of the supernumerary tooth will generally produce beneficial results. The impacted tooth should resume its normal eruptive pattern, but periodic radiographs should be taken to follow its progress.

OVER RETAINED TEETH

A severe strain on the timing so necessary for normalcy in occlusion is found when primary teeth[3] are over retained. The retained teeth act almost like a foreign body[6] in the sense that they are not useful members of the arch and prevent the successor teeth from erupting. Their anatomical configurations do not permit intercuspation, their anteroposterior dimen-

(continued on page 42)

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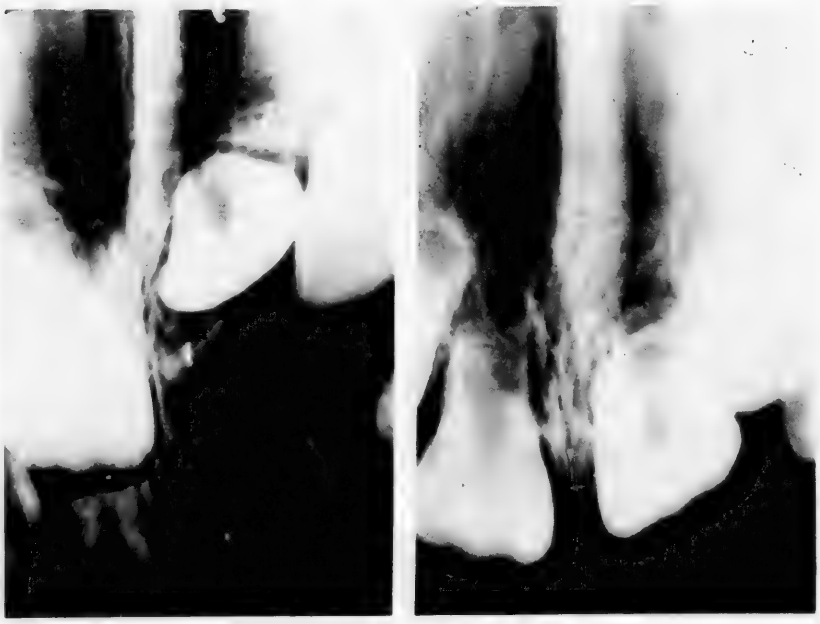


Figs. 4A and B. (left) Trauma was the etiologic factor in the cyst formation in this 5-year-old patient. The pathology appears to be diverting the developing central incisor. (right) Pathology under control and tooth appears to be moving into a more normal position and root development proceeding. Fourteen months between radiographs.

(continued from page 40)

sions adversely influence tooth positioning and quite generally introduce a most abnormal factor in the developing system. Further, an entire tooth need not be involved. Root fragments, ankylosed or not, act in a similar manner and produce changes far out of proportion to their size and position in the jaws.

ANKYLOSIS

Ankylosis is the fusion of bone to the tooth and has several definitive characteristics. Ankylosis is not static nor is it self-limiting and it alone can negate, alter or even destroy many benign forces for a normal occlusion (Figs. 5A, B and C).

This problem of ankylosed molars appears to be primarily one of early diagnosis and the immediate institution of treatment.[4] Once the diagnostic criteria have been met, the dentition is best (Fig. 6) served by immediate removal of the involved tooth or teeth and the insertion of an appliance to maintain the space. The adverse effects of an ankylosed or submerging molar can be transmitted to the (Figs. 7A and B) opposing arch and easily to the entire occlusion. Should the molar remain undetected for any period of time, it may even become covered entirely by soft tissue with a resultant axial convergence of the adjacent teeth. Further confimation of ankylosis may be made by percussing the tooth in question; the result is a solid (Fig. 8) sound giving the feel and impression that the tooth is an integral part of and fused to the skull.

The effect on the developing dentition of one or more of these molars is usually quite marked (Figs. 9A and B). In addition to actual space loss, the lack of alveolar bone formation contributes greatly to any subsequent malocclusion. Delay in the removal of these teeth complicates a surgical problem, inasmuch as they must be removed by dissection and the bone overlying the pre-molar removed. In the maxilla, fusion of these teeth to the sinus floor is generally associated with sino-oral opening upon removal of the offending tooth. Early detection and immediate treatment is indicated for these teeth.

ETIOLOGY AND CHARACTERISTICS

A prime factor in ankylosis, fusion of tooth and bone, is an incomplete or altered periodontal membrane.[2] This membrane, separating cementum and bone, serves to protect the tooth tissues during destructive and constructive phases of great cellular activity; the resorption of primary roots and calcification of its permanent successor. Where this membrane is intact, fusion does not take place and the reverse is true as well. This process proceeds normally but under the influence of trauma or drugs the integrity of the periodontal membrane is breached and ankylosis follows.

A tooth may become ankylosed prior[2] to or after eruption and at any point along its eruptive path. However once the proper ingredients for fusion are present, the tooth ceases eruption and its position in the dental arch becomes fixed. The adjacent teeth and tissue continue their growth and position-

Figs. 5A to C. Three clinical views of ankylosed molars demonstrating the loss of occlusion and fixed position of these teeth in the arch. Untreated, these teeth will initiate a progressively deteriorating occlusion.

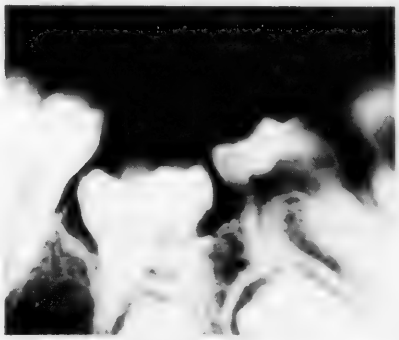
ing and soon the offending tooth actually appears depressed or "submerging" while in fact it is merely fixed in the arch. Should this problem occur early, the depression and an overgrowth of tissues is quite severe and

Fig. 6. This second primary molar exhibits no mobility, elicits a hollow, solid sound to percussion and is beginning to lose its occlusal plane. The root development of the second pre-molar would suggest that it would erupt if the impediment was removed. This represents early ankylosis and should be placed under treatment.

destructive. Once this tooth is so fixed all eruptive forces appear unable to move this tooth into its normal occlusal position in the dental arch (Figs. 10A and B).

Noyes published very early a classical study detailing the histologic and physiologic details of this eruptive problem and indicated the paths of future investigation in this area.[7] His paper delineates the information that dentin, cementum and bone and an interrupted periodontal membrane are all intimately related to produce this situation. He further comments on the hyperactivity of this local area and speculates on this as a prime etiologic factor.

Vorhies *et al*. stated, "Periods of dentin formation and calcification as well as rebuilding of bone are evident in histologic sections. The picture appears to be one in which this double activity of resorption and osseous deposition seemingly bores through solid tooth structure leaving in its wake a typical bone."[8]



Figs. 7A and B. Ankylosis at a more advanced state. In one that successor pre-molar will not erupt until the primary molar is removed and the space retained to permit this and in the other several methods of treatment have been suggested: removal of the primary molar and placement of a fixed bridge or the construction of a casting to establish occlusion and contour.

Biederman discussed the etiology of ankylosis and discounted mechanical trauma as the prime etiologic factor.[2] His preference suggests agreement with Noyes and he presents histologic evidence of unquestionable verity to bolster his position. His clarity of discussion in reference to the site of ankylosis and the cellular activity timing of the phenomena is an excellent example of scientific reasoning. The time period in question presents us with deciduous root resorption and the formation of permanent root structure. As the primary roots are resorbed the periodontal membrane is lost and in that sequence; however should this order be reversed

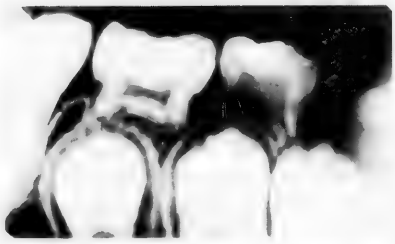


Fig. 8. Ankylosis of long standing or rapid advance and bony infiltration of the pulp chamber of the first primary molar. This 7-year-old patient had a similar pattern on the opposite side. Note there is very little loss of occlusion and it is reasonable to assume ankylosis was initiated after the teeth reach the full eruptive stage.

or altered we could find deciduous root tissue and bone unprotected by periodontal membrane and the possibility of fusion could thus be enhanced. The phenomena of tooth ankylosis in (Figs. 11A and B) deciduous teeth may be explained by this anrhythmic disappearance of the membrane. It would thus appear that the periodontal membrane, its alteration, abberation or loss of continuity is an inciting determinant in this histologic and eruptive drama. Chemical, stimulii or trauma of a chronic nature, may serve as an accomplice to the fact of tooth and bone fusion.

DIAGNOSIS AND TREATMENT

The criteria for diagnosis are both clinical and radiographic and require careful evaluation. The diagnostic routine must be early and definitive as the ill effects of fusion are progressive and productive of continuous ills at an accelerating rate.

The clinical signs are: (1) Loss of occlusion with the opposing tooth. If of long standing the adjacent teeth incline axially to reduce the occlusal clearance

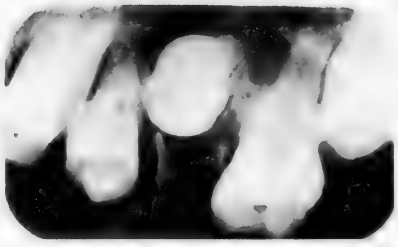
Fig. 9A. Long standing ankylosis of maxillary second molar. Note bony infiltration of pulp chamber.

Fig. 9B. Undiagnosed ankylosis in maxilla with treatment deferred. Observe mesial migration of first primary molar and the deviation of the second pre-molar.

and chronic irritation of the tissues is quite apparent. (2) Complete lack of mobility of the tooth concerned. This tooth is fixed, firm and impossible to move. The impression gained by any manipulation is one of the tooth being an extension of the maxilla and mandible. (3) Percussion produces a clear sharp sound; unlike one produced by testing a normally erupted tooth.

RADIOGRAPHIC SURVEY

Radiography may demonstrate a lack of or interruption in the continuity of the periodontal membrane. Long standing cases may demonstrate bony invasion of the pulp chamber, replacement of the cementum and dentin. These changes are minimal in the early stages of fusion and continuous observa-



Figs. 10A and B. Root fragments, which may be ankylosed, serve to destroy a normal eruptive pattern. They should be regarded in a similar way to a fully overretained tooth.

tion and examination are essential.

The confirmation of ankylosis should initiate immediate treatment consisting of the removal of the offending tooth and the bony cap covering the successor. The progressive nature of the problem begs for early intervention but still another facet, that of bone growth and deposition, should be considered. Bone growth is intimately involved in the eruptive process and bears some examination. Bone growth and tooth eruption proceed in the direction of diminished resistance and will be inhibited in an ankylosed area. Inasmuch as bone grows by surface deposition and resorption, no new bone can be formed until the tooth is removed and so further underlines the need for early intervention. Thus the creation of a new bony surface at the site of the removed tooth will decrease bone loss and remove the inhibition of alveolar

Figs. 11A and B. Two maxillary ankylosed molars which were completely covered by the oral soft tissues. They were discovered by the physician seeking cause of chronic sinus drainage and infection. The removal of these teeth required hospitalization and rather extensive surgical treatment.

growth and this in turn minimizes the resultant bony area defect which would be present with any delay.

Should early diagnosis and effective treatment be compromised the following clinical situation may be encountered: (1) Ankylosis has fixed the tooth in a "submerged" and abnormal position. The adjacent teeth in various stages of axial deviation. (2) Deficient alveolar bone growth. (3) Progressive degeneration of occlusion (Fig. 12).

SUMMARY

Tooth ankylosis is due to a periodontal membrane alteration allowing a fusion of tooth and bone. These teeth cease

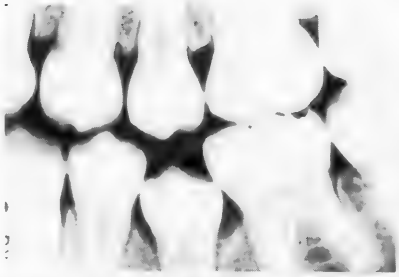


Fig. 12. The mandibular second primary molar was ankylosed and removed; however space was not maintained with the above result.

eruption at the time of ankylosis and cannot move or be moved. The mandibular second deciduous molar is most commonly affected. Teeth below the level of occlusion they once reached, percuss with a solid sound and demonstrate an interrupted periodontal membrane are prime suspects. Histologically these areas are in a condition of great cellular activity, both resorption and calcification, and fusion of bone and tooth occurs. Diagnosis of this condition in its incipient stages, and proper treatment will greatly minimize the progressive ill effects on the dental condition.

The practitioner involved in treating the young child must include in his armamentarium a consuming curiosity concerning abnormalities in the dentition of his patients (Fig. 13). His investigative instincts must have proper place in his evaluation of normalcy or for a specific situation. Proper preparation for dental guidance must have, as a high priority a thorough and current knowledge of what is proper in this particular oral apparatus, what will progress to

Fig. 13. This mandibular permanent first molar is unerupted at age nine. The other molars are in normal occlusal position and the etiology of this abnormality is under question at present. The diagnosis of follicular cyst formation and ankylosis has been suggested.

normalcy and what will degenerate toward malocclusion. Some small, distant decision to act or not to act, may in the end, determine dental harmony.

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Early Detection of Head and Neck Cancer Using Oral/Facial Self-Examination

John C. Grabau, M.P.H.* and Stanley J. Scott, D.D.S.**

Treatment for advanced malignant neoplasms of the oral cavity often involves radical surgery, radical radiotherapy or a combination of both. Unfortunately, extensive therapeutic intervention, especially by surgery, in this anatomical area is particularly apt to lead to functional impairment and/or physical disfigurement. Although there may be some controversy over what modality or what sequence of modalities is most effective as a function of: disease location, histology and stage, most clinicians agree that early stage lesions (*i.e.* small in size and without lymphatic involvement) offer the most promising prospects for long term, high quality survival.

There have been a number of investigations into the association of various demographic, chemical and mechanical factors with cancer of the upper aerodigestive tract. These studies suggest a profile of individuals at high risk for developing oral cancer. Heavy tobacco use and high alcohol consumption have been specifically implicated as agents operating in oral carcinogenesis.[9,10,13] Risk increases markedly with age and also is substantially greater for males than females.[4] A cirrhotic liver has been associated with cancer of the floor of the mouth, however, a relationship at other oral sites has not been demonstrated.[8]

In Puerto Rico, Martinez[11] compared dietary habits of 400 patients with epidermoid cancer of the esophagus, mouth, and pharynx with three controls, matched for age, sex, and socioeconomic status. He found the disease to be associated with a high consumption of hot beverages and spices, as well as high alcohol and tobacco consumption.

Data from the Third National Cancer Survey in Table 1 yields a median age of onset for cancers of the lip, tongue, salivary gland, and gum and mouth of approximately age 62 for both males and females in the white population. The non-white population shows an earlier median age of onset, *viz.*, 57 and 52 for males and females respectively. The morbidity and mortality rates are approximately three times as great for males as for females, independent of race. Morbidity rates for whites exceed those for non-whites, however, the pattern reverses when mortality is considered.

Farr and Arthur have noted that "Metastasis to cervical nodes in cancer of the head and neck is of grave import, a biological phase in the pathogenesis of this disease of far greater significance than local geographic size, extent, or duration of the primary tumour."[5]

Booze and Asal have pointed out that "Cancer of the buccal cavity and pharynx does not kill many people when measured absolutely or proportionately. As a per cent of all cancer deaths, oral cancer contributes about two to three per cent. However, so many deaths from a site so easily observable provides impetus for more intensive educational and case-finding efforts, particularly in view of the favorable prognosis for survival when detected early."[2]

Clearly then, efforts to control oral cancer must focus on discovering the disease before the lymphatic system becomes involved. Screening programs, public awareness campaigns, and other measures to expand the population which benefits from periodic comprehensive head and neck exams (annually or semiannually) would be helpful. However, it is unrealistic to expect more than a small percentage of the total population (even of high risk groups) to be so involved. As a tactic for achieving more widespread coverage, it may be useful to borrow a concept from the gynecologist. Breast self-examination, popularized in recent decades, has demonstrated notable gains in early detection of tumors.[3] The self-exam has been shown to be of value even when used in conjunction with periodic screening. Over 10% of the cancers found in a recent series at the Guttman Institute were detected by the patient as a breast lump via self-examination between regular annual comprehensive breast screening examinations.[12] Generalization to the oral site is achieved by developing a simple, yet thorough protocol for oral self-examination which can be effectively taught to the general population.[1,6,7] Five minutes of instruction from a dentist, physician, specially trained dental auxiliary or nurse can provide enough understanding for individuals to be able to examine themselves with reasonable effectiveness in search of oral abnormalities.

Oral self-examination can easily be taught in the dental or medical office. The only materials needed are a gauze compress and a lighted mirror (an illuminated table model "make-up mirror" is especially well suited for use in the clinical setting). A bathroom mirror, as found in most homes, is usually sufficient for continued practice of the technique. During the course of instruction the patient should be made

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Table 1. Morbidity and Mortality from Malignant Neoplastic Disease of the Buccal Cavity by Race and Sex in the United States

	Median Age at Diagnosis* (years)	Median Age at Death** (years)	Rate per 100,000 Incidence*	Rate per 100,000 Deaths**
White Males	62.0	64.4	11.4	4.4
White Females	62.4	66.4	4.2	1.3
Non-White Males	57.5	58.4	8.9	5.8
Non-White Females	54.2	55.1	4.0	1.7

* U.S. Department of Health, Education and Welfare, National Center for Health Statistics. Current Estimates from the Health Interview Survey, United States, 1971. Vital and health statistics; Ser. 10, No. 79, DHEW, Pub., No. (HSM) 73-1505. Washington, DC, Government Printing Office, 1973.

** Segi, M., Kurihara, M. Cancer Mortality for Selected Sites in 24 Countries No. 6 (1966–1967). Japanese Cancer Society (November), 1972.

aware of the fact that there are many kinds of lesions that can occur in the oral cavity, that some are harmless but others are of a more serious nature. The scope of instruction should not include information which might encourage "self-diagnosis." Rather, the patient should learn what is normal for his mouth and be alert to any changes which persist for longer than two weeks. Any change which does not return to normalcy within that time should be reported to a dentist or physician so that a proper diagnosis can be made.

During the instruction a mirror should be used to allow the patient to practice the self-exam under direct supervision of the instructor. The following protocol is suggested: (1) Facial Exam—Glasses should be removed to permit an unobstructed view of the region surrounding the eyes and nose. The skin of the face, lips, and neck should be checked for changes in skin color, lumps, and sores. (An older individual's facial wrinkles surrounding the eyes may hide basal cell carcinomas. Special attention should be given to this area to be sure that all folds are carefully investigated). Upon completion of this step the glasses should be replaced. (2) Outer Cheek Area—Press lightly with the fingers feeling for lumps or numbness. (The maxillary sinus is of prime interest in this step but lymph nodes in this region may also be detected.) (3) Neck Region—Press lightly on the neck to detect any lumps or tenderness. (Particular attention should be given to the parotid gland and jugular chain of the cervical lymphatic system). (4) Roof of the Mouth—Tilt the head back and open the mouth wide to observe any color differences or lumps. (Dentures should be removed for this and all subsequent steps). (5) Cheek Area—Use the fingers to expose the inner cheek surface to observe any white, red or dark patches. Place the thumb on the inside and the index finger on the outside of the cheek, gently squeeze the cheek checking for any lumps or areas of tenderness. (6) Lips—Pull the lower lip down to view any possible sores or color changes. With the fingers feel for any lump which may not be seen. Repeat the procedure for the upper lip. (7) Floor of Mouth and Tongue—Place the tip of tongue to the roof of the mouth. Examine the floor of the mouth by gently pressing with a finger to detect any abnormal lumps or sores. With the tongue still up, check the under surface of the tongue for color changes. Extend the tongue and inspect the top surface. Using a gauze compress or a tissue, gently but firmly grasp the tongue and pull it forward to view the sides. Any swelling or color changes should be noted.

In the course of the self-exam instruction the patient should be made aware of the concept of oral/facial symmetry and the association of asymmetry with possible abnormality. To illustrate the usefulness of this concept, palatine or mandibular tori or the soft tissue covering the orifice of the parotid duct may be pointed to as typically symmetric oral structures.

Upon completion of the self-exam instruction, warning signs should be emphasized. The presence of any of the following signs in the mouth or on the face or neck for more than two weeks should be cause to take positive action. (1) Sores (2) White, red or dark patches in the mouth (3) Pain or loss of feeling (4) Swellings, lumps, or growths (5) Bleeding for no apparent cause.

Although the thrust here is on detection of oral/facial cancer, it must be anticipated that individuals will identify non-malignant neoplasms or lesions which require clinical attention. Assorted cysts, abscesses, fibromas, hemangiomas, periodontal diseases as well as a variety of other problems may be identified. The patient should be reassured that any abnormality found in the mouth is not necessarily cancer but, should it persist, it should be brought to the attention of a dentist or physician for appropriate clinical intervention.

Figure 1 shows a pamphlet developed for use in conjunction with instruction in oral/facial self-examination. The "student" is encouraged to retain the pamphlet to serve as a reminder of the steps to be taken to insure that all sites are checked.

Although the above discussion has presented the teaching of oral/facial self-examination in the context of a private dental or medical office, it should be clear that it can also be provided as a public education program operating through various centers of community activity.

The first large scale implementation of the self-exam instruction was held at a county fair in suburban Buffalo, New York, in 1975, under the exhibit title "Meet Your Mouth."[7] At that time over 450 individuals received one-on-one instruction in the technique. A follow-up study was conducted three months after the fair on a sample of those who had received the instruction. About half of the respondents reported that they did a self-exam at least three times during the three month intervening period. Analysis of results from another follow-up study conducted 8 months after the fair to assess the longer term utilization of the self-exam, is not yet completed.

Early detection and prompt treatment of oral/facial cancer can have a major impact in reducing the mortality and enhancing the quality of survival of persons afflicted with the disease. It should be emphasized that self-examination is not a replacement for a comprehensive head and neck examination done as part of routine dental and medical checkups. Rather, oral/facial self-examination must be considered a new component of the individual's own commitment to personal preventive health practices.

WARNING SIGNS:
1 - Sores that do not heal within two weeks
2 - White, red, or dark patches in the mouth
3 - Pain or loss of feeling in any area of the mouth
4 - Any swelling or growth
5 - Repeated bleeding for no apparent cause
If you have any of these signs you should see your dentist or physician immediately!
There were over 8,000 deaths in the United States from cancer of the mouth and throat in 1976. Approximately 23,000 new cases of this disease were detected that year. Many of these patients required extensive surgery, some resulting in disfigurement or disability. The tragic consequences of cancer can be reduced by early detection and prompt treatment. This folder shows you how to examine your mouth and neck so that you may alert your dentist or physician to early signs of possible cancer.
prepared by:
Eastern Great Lakes Head & Neck Cancer Control Network
and
Department of Oral Medicine
State University of New York at Buffalo
2121 Main Street
Buffalo, New York 14214
4/76
EARLY DETECTION of ORAL CANCER MAY SAVE YOUR LIFE
A mirror and adequate lighting are necessary for the self-examination.
1. Facial Exam
If glasses or dentures are worn, it is necessary to remove them. Inspect the skin of the face, neck and lips. Be sure to look closely at the area around the eyes and the bridge of the nose. Look for changes in skin color, lumps and sores. Replace glasses.
2. Outer Cheek Area
Press lightly with your fingers feeling for lumps or numbness
3. Neck Region
Use your fingers to press lightly to detect any lumps or tenderness
4. Roof of the Mouth
Tilt the head back and open the mouth wide to observe any color differences or lumps
5. Cheek Area
Use your fingers to expose the inner cheek surface to observe any white, red or dark patches. Place your thumb on the inside of your cheek and your index finger on the outside. Gently squeeze your cheek between your fingers, check for any lumps or areas of tenderness
6. Lips
Pull the lower lip down to view any possible sores or color changes. With your fingers feel for any lump which may not be seen. Repeat procedure for upper lip.
7. Floor of Mouth and Tongue
Place the tip of the tongue to the roof of the mouth. Examine the floor of the mouth by gently pressing with your finger to detect any abnormal lump or sore
With your tongue still up, check the under surface of the tongue for color changes
Extend the tongue and inspect the top surface
Using a gauze compress or a tissue, gently but firmly grasp the tongue and pull it forward to view the sides. Any swelling or color changes should be noted

Fig. 1. Pamphlet utilized for teaching oral/facial self-examination

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YEARS IN PRACTICE	6 ☐ Dental Assistant	6 ☐ Other _____
6 ☐ Less than 2	7 ☐ Other _____	
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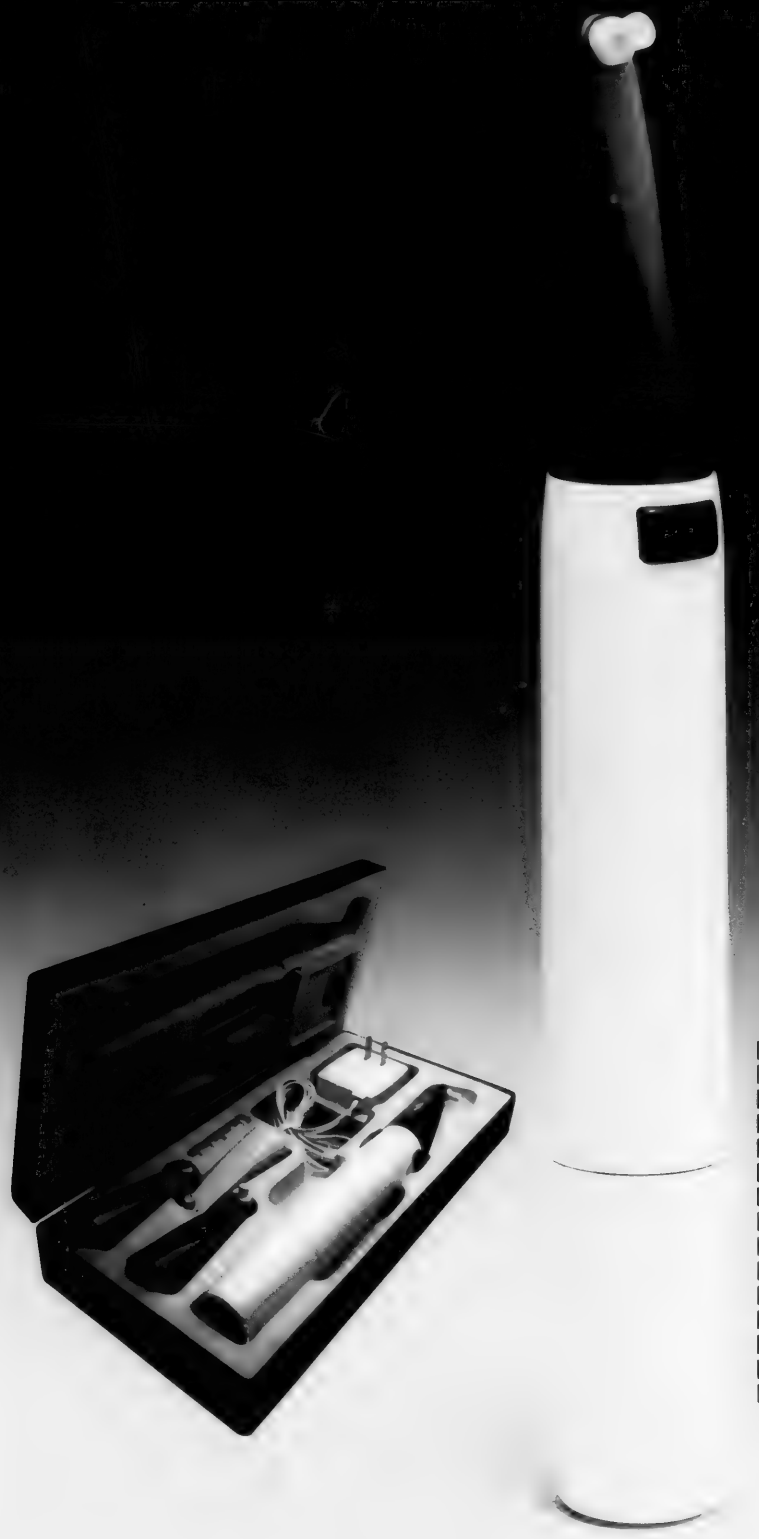
The new incentive for home preventive dental care.



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PD1077

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A 2-second test that can make the time between visits less painful

And can improve the outlook for the next checkup.

A survey of dentists indicates that tooth hypersensitivity can be found in every seventh patient in the average general practice.[1] But there may be many other undiagnosed patients who don't complain because they consider it "normal" or unimportant. So they may suffer in silence, risking the possibility of more serious pathology.

Tooth hypersensitivity vs. preventive home care

Patients with sensitive teeth tend to avoid brushing sensitive areas.[1] "This appears to be related to the fear of causing pain ...with the toothbrush."[2] And when, for any reason, "tooth-brushing is stopped and the bacterial mass [within the plaque] is allowed to accumulate...clinical signs of gingival inflammation become apparent."[3]

A 2-second test for tooth hypersensitivity

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References: 1. Data on file, Block Drug Company, Inc. 2. Abstract of the Symposium on Mechanisms of Pain and Sensitivity in the Teeth and Supporting Tissues, Fairleigh Dickinson University School of Dentistry, Nov. 12-13, 1973, p. 15. 3. Goldman, H. M. and Cohen, D. W.: An Introduction to Periodontia, Fourth Edition, The C. V. Mosby Company, St. Louis, 1969, p. 74.

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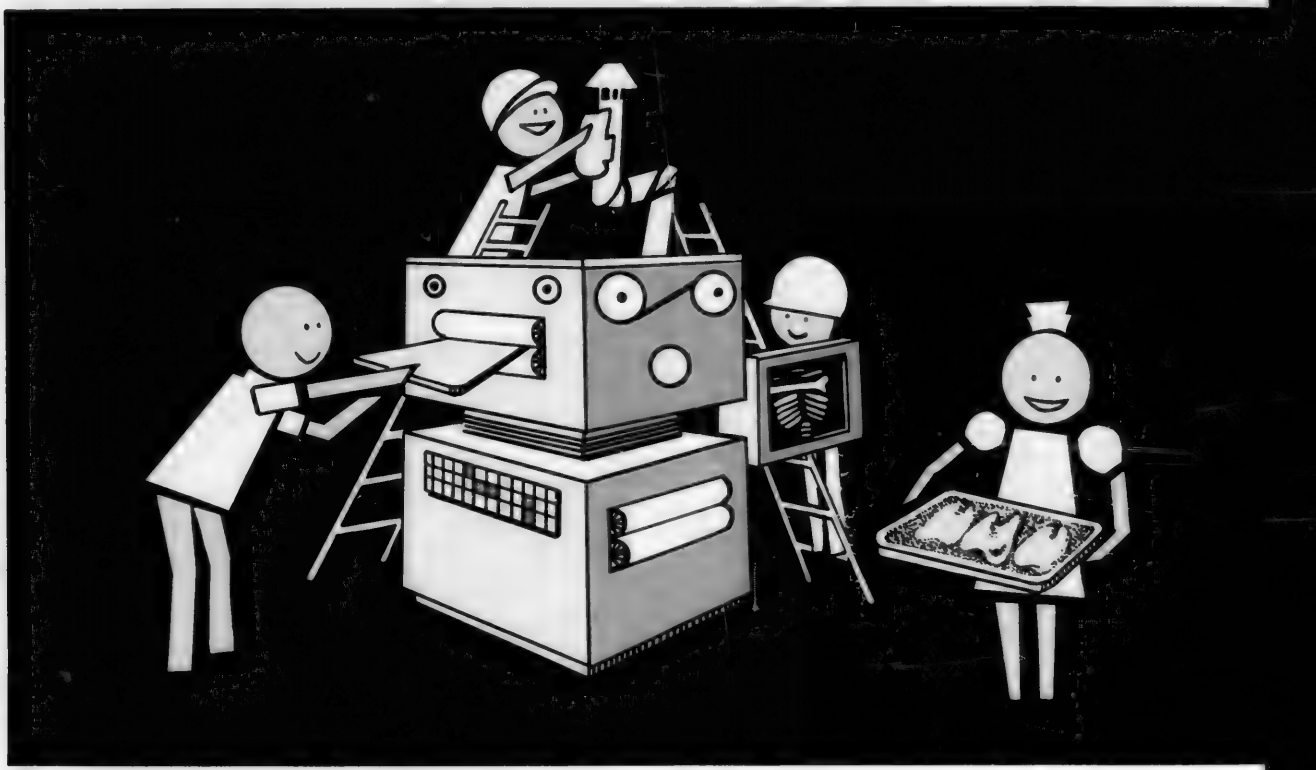

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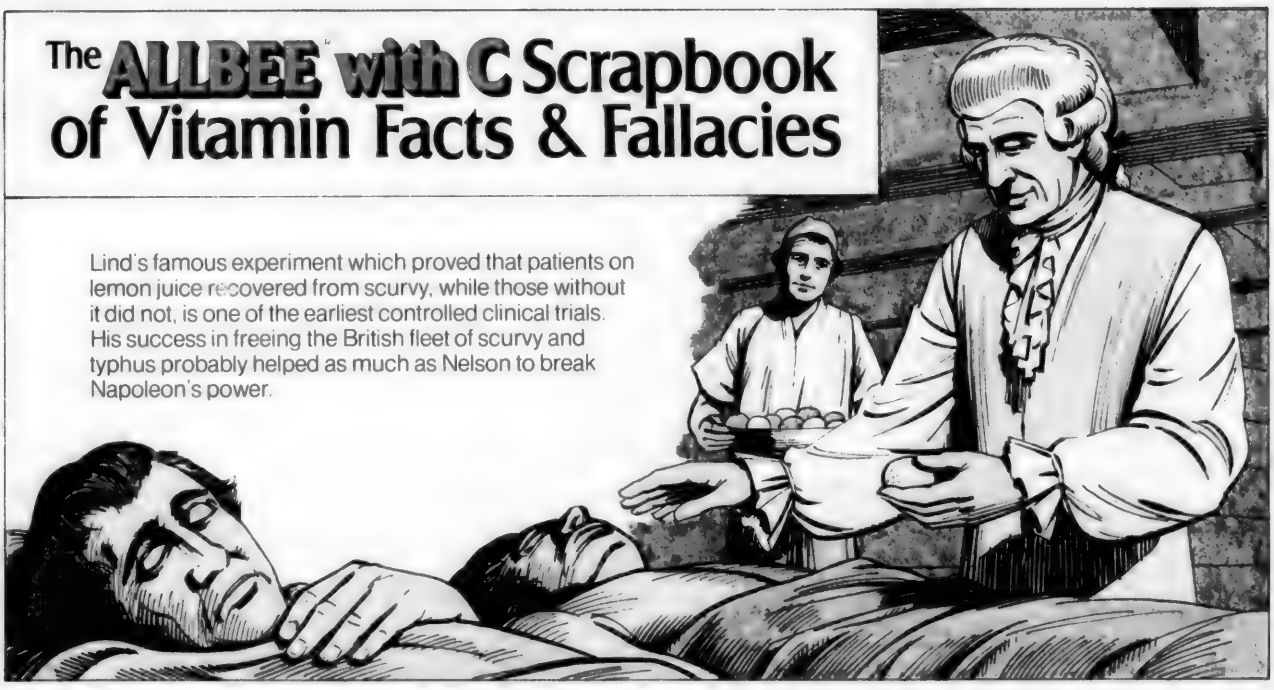

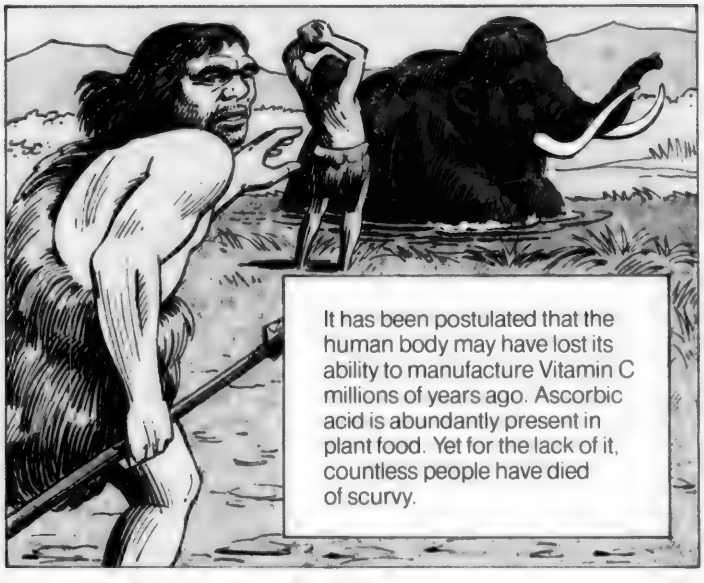

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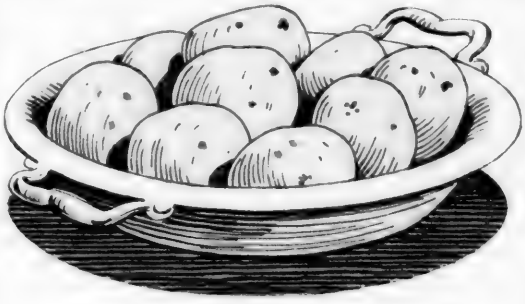

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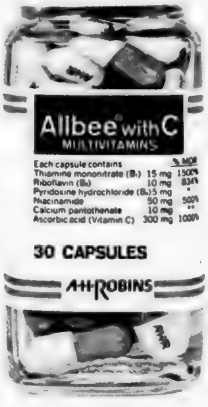

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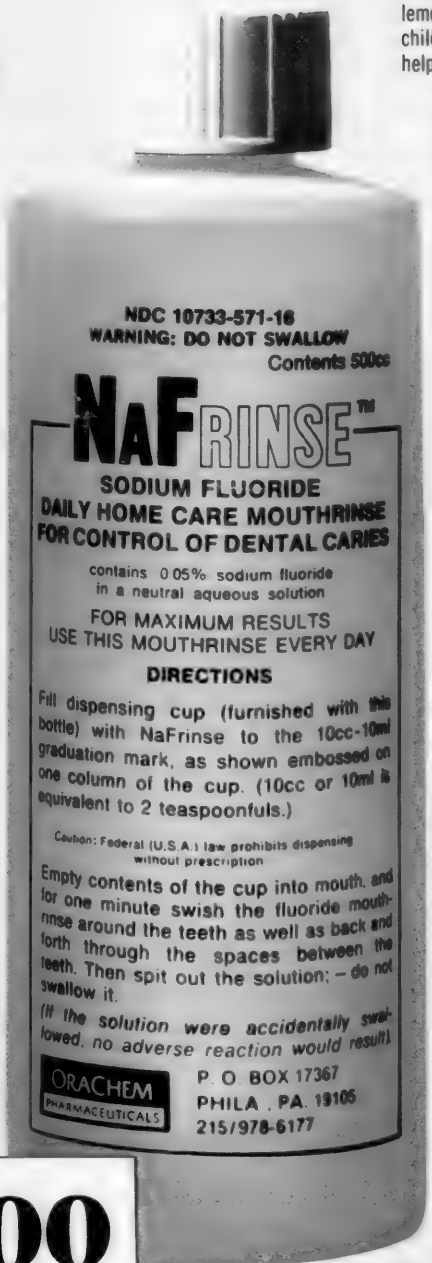
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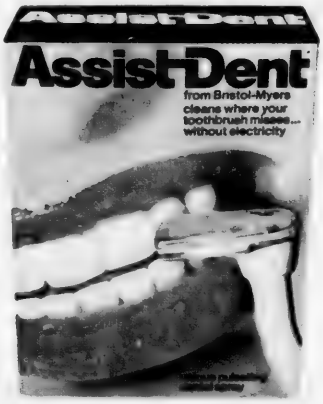

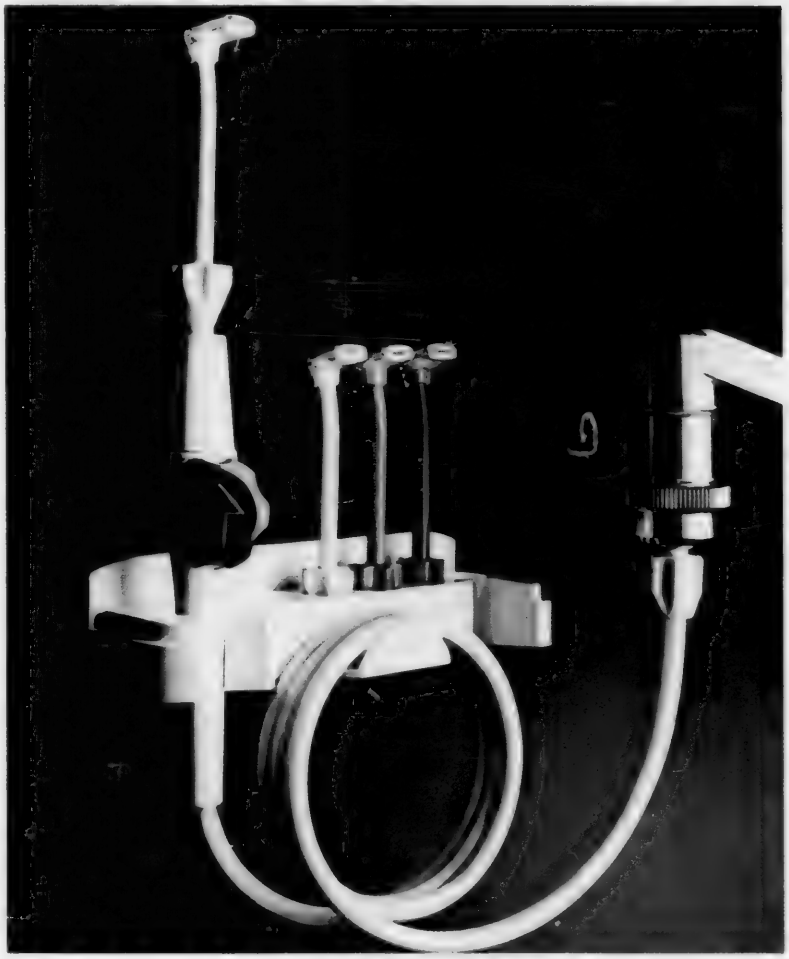

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THE JOURNAL OF
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contents

8 Factors that Influence Quality of the Dental Radiograph
C. Larry Crabtree, D.D.S.

18 Automatic Film Processing
Kavas H. Thunthy, B.D.S.

20 Preventive Care and Maintenance of the Automatic Dental Film Processor
A. Peter Fortier, D. D. S.

23 Histologic-radiographic Relation of Proximal Surface Carious Lesions
Robert E. Buchholz, D.D.S.

25 Research Annotation of the Effect of Urea Peroxide Solution on Dental Plaque
J. H. Manhold, D.M.D. and E. A. Manhold, B.S.

28 Reduction of Baseline Gingivitis Scores with Repeated Prophylaxes
Kristin Talbott, M.D.H., Irwin D. Mandel, D.D.S. and Neal W. Chilton, D.D.S.

30 Prescribing Low Potency Fluorides for Frequent Use
Frederick M. Parkins, D.D.S.

37 The Swine Flu Program: Some Thoughts for Preventive Dentistry
H. Barry Waldman, D.D.S.

39 Indexes to volume 4

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Factors That Influence Quality of the Dental Radiograph

C. Larry Crabtree, D.D.S., M.S.*

It is not easy to interpret a perfect roentgenogram (radiograph). It is impossible to interpret an imperfect one.[4]

A dental radiograph provides diagnostic information through differential absorption of the X-ray beam.[1] A three-dimensional object is recorded as a two-dimensional image with a finite informational content, which is determined by various physical factors, many of which are under the dentist's control. The informational content is influenced by: (1) density; (2) contrast; (3) sharpness; (4) distortion; and (5) artifacts. This paper discusses each item in detail.

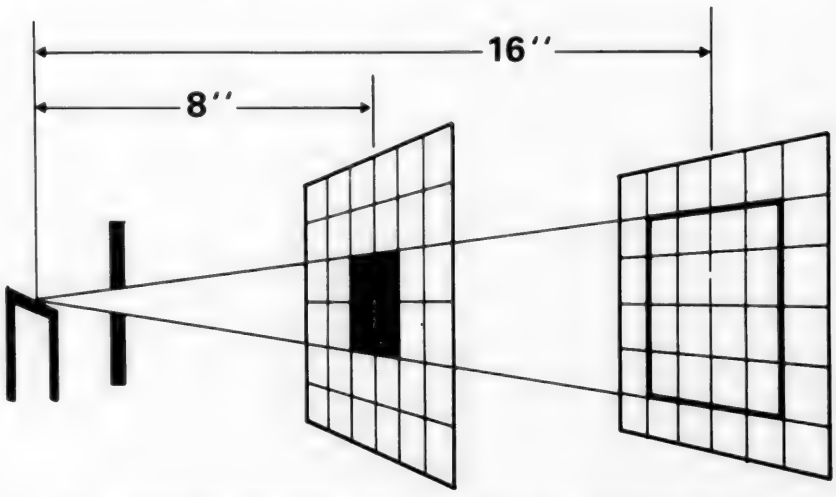


FIG. 1. Intensity of X-ray beam is altered by changing the source-to-film distance.

DENSITY

The first factor, density, is a measure of the blackness of the radiograph. The degree of blackness is affected first by the amount of radiation reaching the film; second, by the sensitivity of the film to radiation; and third, by the manner in which the film is processed.[7]

The amount of radiation reaching the film is directly proportional to the tube current (milliamperage) and the exposure time, when tube potential (kilovoltage) and distance from the X-ray tube to the film plane remain constant.[4] Total radiation output is related to milliampere-seconds (mAs) of exposure. For example, a one second exposure at 5 milliamps gives 5 milliamp-seconds. A ½ second exposure at 10 milliamps or a ⅓ second exposure at 15 milliamps also gives 5 milliamp-seconds. A word of caution: dental surveys have shown that many timers, both mechanical and electronic, are neither accurate nor consistent.[6] Therefore, it is advisable that the dentist establish a setting on the timer which will give the desired film density for each projection. Inconsistent timers, as evidenced by radiographs of inconsistent density within groups processed together, must be repaired or replaced.

Raising or lowering the kilovoltage will also affect the quality and quantity of radiation reaching the film. With mAs held constant, an increase in tube voltage increases the quantity of radiation and the range of energies present in the beam.[5] If radiographs

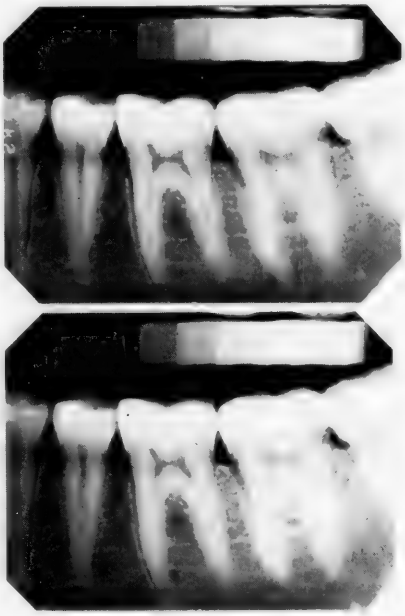


FIG. 2. Use of "D" speed film reduces skin exposure. (Top) "D" Speed, Skin EXP = 300 mR. (Bottom) "C" Speed, Skin EXP = 600 mR.

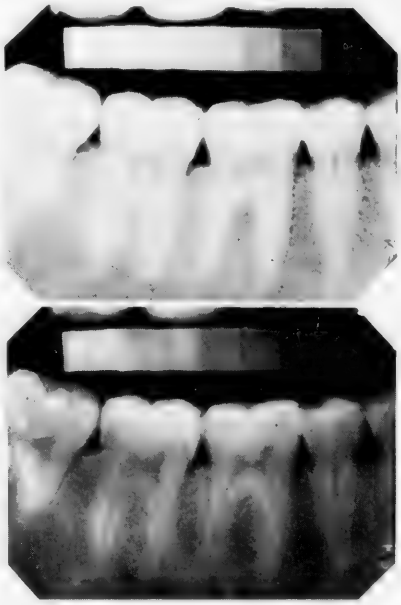


FIG. 3. Processing cannot compensate for errors in exposure. (Top) underexposed and overdeveloped. (Bottom) Overexposed and underdeveloped.

* Division of Training and Medical Applications, Bureau of Radiological Health, Food and Drug Administration, 5600 Fishers Lane, Rockville, Maryland 20857.

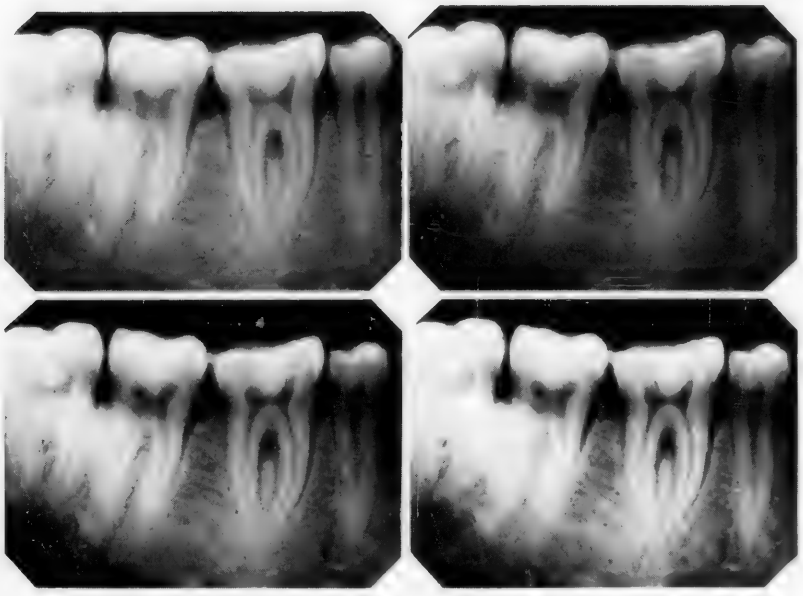


FIG. 4. Kilovoltage settings affect subject contrast. (Top left) 90 kilovolts. (Top right) 75 kilovolts. (Bottom left) 65 kilovolts. (Bottom right) 50 kilovolts.

Another factor that affects film density is the nature of the patient or structures being radiographed. Thick or dense anatomical structures will absorb a larger portion of the X-ray beam. Thus, mAs or kilovoltage must be increased to compensate for the increased amount of attenuating material.

The speed, or sensitivity, of the film determines the amount of radiation needed to produce the desired image density. Fast film–"D" speed group–requires about half as much incident radiation as the slower "C" speed film. In Figure 2, the "D" speed film on the left was produced with half the radiation of the "C" speed film on the right. The quality of the radiographic images appears equal; yet the patient was exposed to twice the radiation with "C" speed film. There is little justification for using "C" speed film.

(continued on page 12)

are exposed at the same mAs, but at different kilovoltages, the radiographic image will be more dense at the higher kilovoltage. Any change in kilovoltage requires a change in mAs if the image density is to be constant.

The amount of radiation reaching the film is also a function of the source-to-film distance, as expressed in the inverse square law: the intensity of the radiation is inversely proportional to the square of the distance.[6] If the source-to-film distance is doubled, the divergence of the X-ray beam produces an area which is four times the original as shown in Figure 1. Hence the amount of radiation incident on the original area at the greater distance will be reduced to one-fourth. If the dentist converts from an 8″ to 16″ source-film distance, the mAs must be quadrupled to produce the same image density.

FIG. 5. Light leaks or incorrect safelighting causes fogging of films.

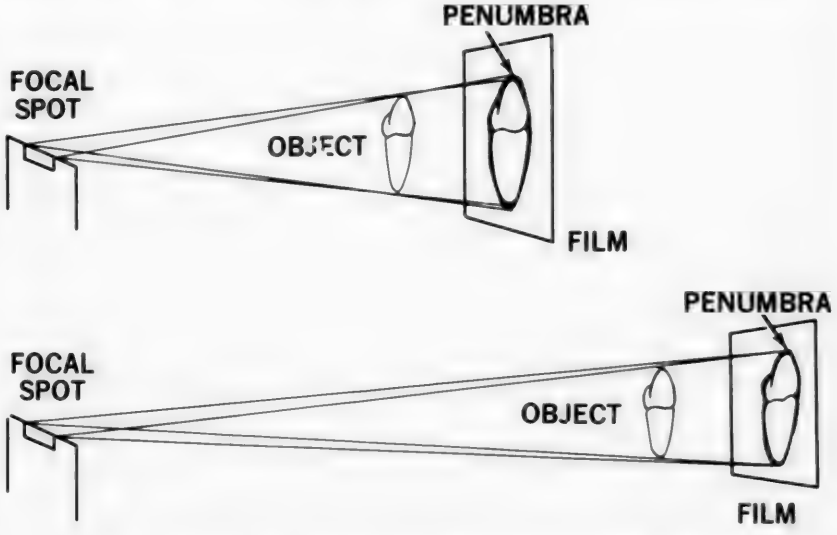


FIG. 6. Increasing the source-to-film distance improves image sharpness.

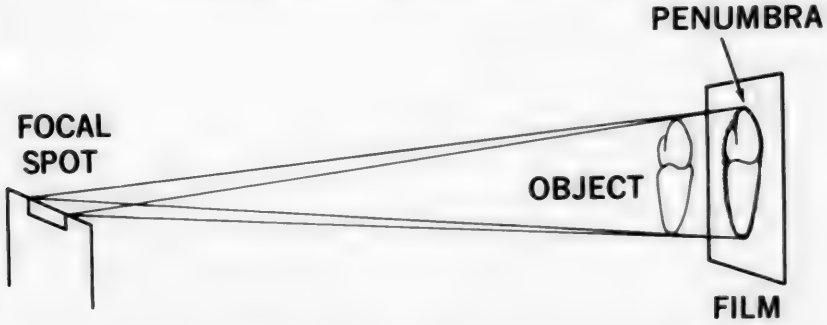
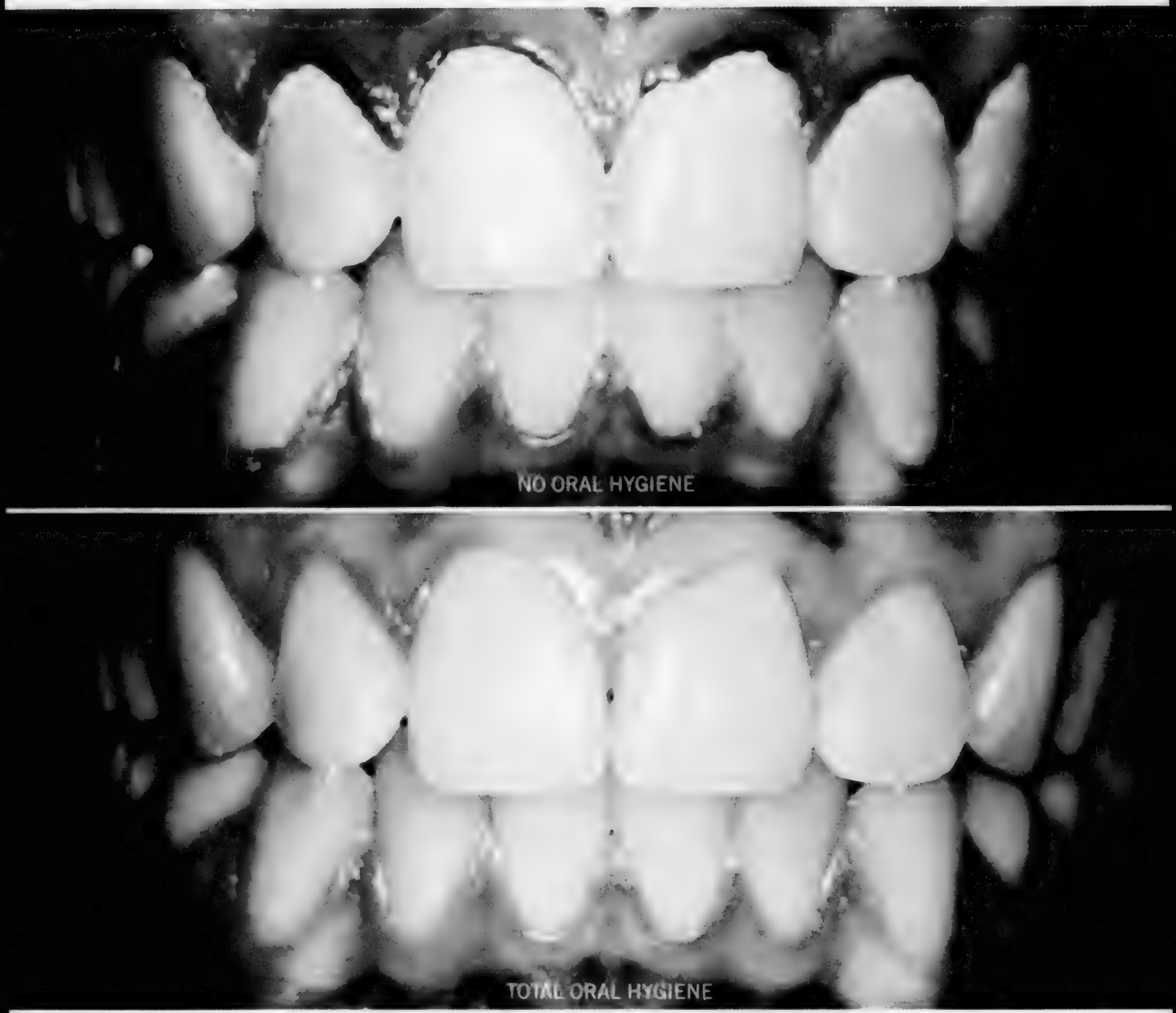


FIG. 7. Positioning film close to object improves image sharpness.

A DIFFERENCE YOU CAN SEE.



EFFECTIVE REMOVAL OF HEAVY PLAQUE BUILD-UP.

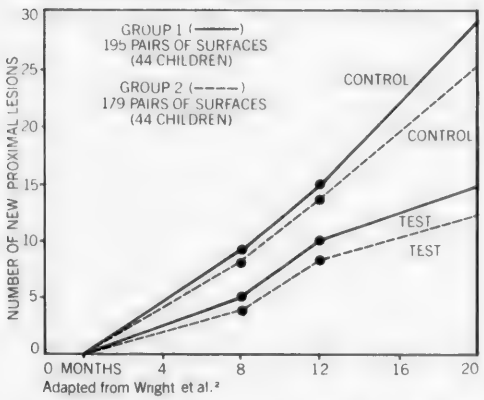
The photographs above show the dramatic difference just one week of regular flossing and brushing can make in the removal of heavy plaque build-up. The subject was a dental student volunteer who flossed and brushed regularly. He was asked to stop all oral hygiene for a period of three weeks, at which point the photograph at the top was taken. Note the extensive plaque accumulation and mild gingivitis. One week after the subject resumed regular flossing and brushing, the photograph on the bottom was taken. Accumulated plaque has been removed and gingivae have resumed their firm, pink, healthy look.[1]

A DIFFERENCE YOU CAN LOOK FOR.

FLOSSING ADDED TO BRUSHING DRAMATICALLY REDUCED INTERPROXIMAL CARIES.

The effect of flossing in reducing the incidence of dental caries on interproximal surfaces was recently reported in a 20-month study[2] of 88 first-grade children. The study involving two groups of 44 children was conducted in a fluoride-deficient area, and compared the incidence of caries on the control unflossed side of the subject's mouth with its flossed contralateral counterpart. Regular flossing was performed by trained assistants using a standardized technique.

EFFECT OF FLOSSING ON INTERPROXIMAL DENTAL CARIES



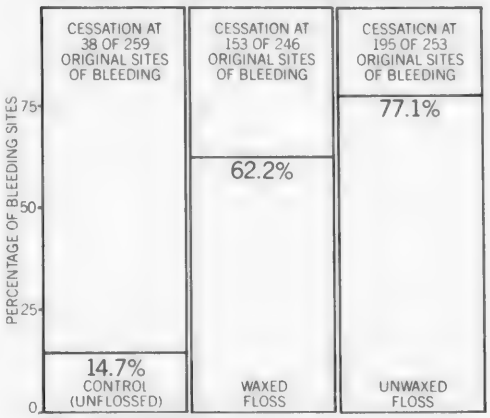
Adapted from Wright et al.[2]

As the chart illustrates, when the data from the two groups is combined, the flossed surfaces were found to have 53% fewer cavities than the control surfaces. The investigators noted the incidence of caries for both tests and controlled surfaces was almost identical when flossing was discontinued for 4 months.

FLOSSING ADDED TO BRUSHING SIGNIFICANTLY IMPROVED GINGIVAL HEALTH.

Regular flossing, by removing food particles and plaque, can improve gingival health and may also prevent the progression of periodontal disease. This was demonstrated in a recent study[3] of sixty patients with a high incidence of sulcular bleeding. The subjects were divided into either a control or a floss group. At the start of the study, a count was made of all bleeding sites. The test group was then instructed in the technique of flossing. After eight days, the original sites of bleeding were re-examined. As the graph below shows, when flossing was added to a program of oral hygiene, sulcular bleeding was significantly reduced.

EFFECT OF PATIENT-ADMINISTERED FLOSSING ON SULCULAR BLEEDING



Adapted from Carter et al.[3]

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References. 1. Loe, H. *et al.*: *J. Periodontol.* 36:177, May-June (1965) 2. Wright, G.Z. *et al.*: Presented at the International Association of Dental Research Meeting in Copenhagen, *J. Dent. Res.* 56 (Special Issue A): Abstr. 168 (1977). Interim Findings, *Caries Res.* 10 (No. 5) 379-385 (1976); *J. Dent. Res.* 56(6): 574-578 (1977). 3. Carter, H.G. *et al.*: *Va. Dent. J.* 52:18-32 (1975)

Johnson's DENTAL FLOSS

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FIG. 8. Motion during exposure reduces image sharpness (Tubehead vibration, Patient movement and film movement).

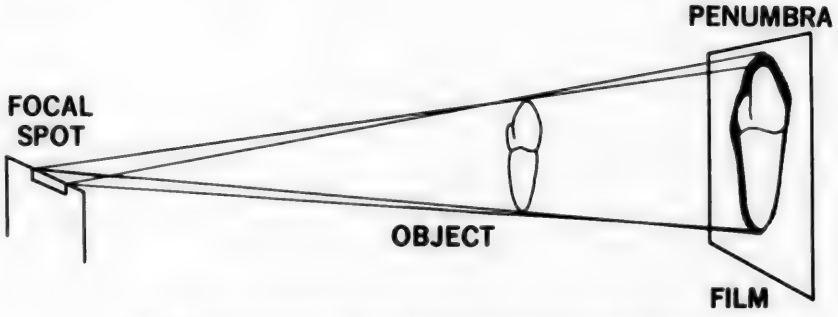

FIG. 9. Increasing the object-to-film distance magnifies the image.

(continued from page 9)

Film processing demands strict attention to recommended procedures in order to obtain optimum film quality and readability. Full development of the image can always be attained if the developing solution temperature is routinely determined or regulated and the appropriate time–temperature chart is consistently followed.[2]

A film which is light, and yet was properly exposed, can usually be traced to one of the following processing errors: (1) developing time was too short for the temperature of the solution; (2) developing solution was too cold for the time used; or (3) developing solution was weak because of improper preparation or overuse.

A severely darkened film can result from developing too long, usually over 20 minutes, or from developing in too high-temperature solutions. Adjustments in processing cannot adequately compensate for errors in exposure. In Figure 3, the film on the left was underexposed and then overdeveloped. Although optical density has increased, image quality is poor. The film on the right was overexposed and underdeveloped. Although the radiograph shows an image, informational content has been degraded.

CONTRAST

The next measure of radiographic quality is contrast. It is defined as the difference in density among various parts of the image and is controlled by both subject contrast and film contrast. Subject contrast is the result of differential X-ray absorption within the anatomical structures under examination, whereas film contrast is affected by the type of film used and the developing process.[6]

Subject contrast decreases with increased kilovoltage. Increasing the kVp setting increases the penetrating power of the X-ray beam and reduces the differences in density between various parts of the image. In Figure 4, the upper left film was exposed at 90 kilovolts and shows less contrast than the films exposed at 75, 65, or 50 kVp.[10]

In dental radiography the dentist is looking for pathological changes in hard tissues, *i.e.*, in bone, enamel, dentine, and cementum. Although the hard structures are easily distinguishable at 50 and 90 kilovolts, as well as at intermediate energies, we have little data to support a decision on which kilovoltage setting will best detect certain pathological changes. The objective in selecting tube voltage to produce optimum contrast is to depict on the radiograph all the observable tissues and their relative radiopacities and radiolucencies with absolute fidelity.[9]

(continued on page 14)

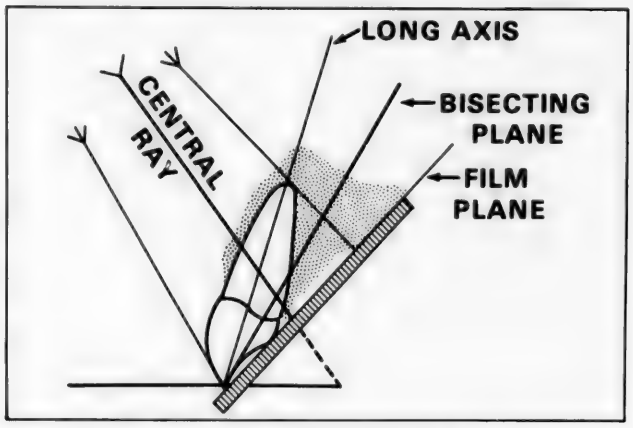

FIG. 10. Excessive vertical angulation causes foreshortening of image.

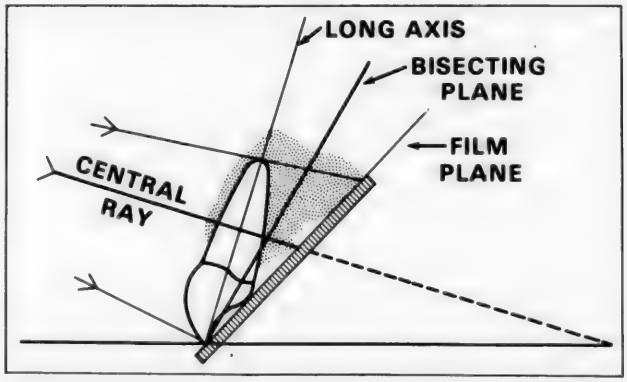

FIG. 11. Too little vertical angulation causes elongation of image.

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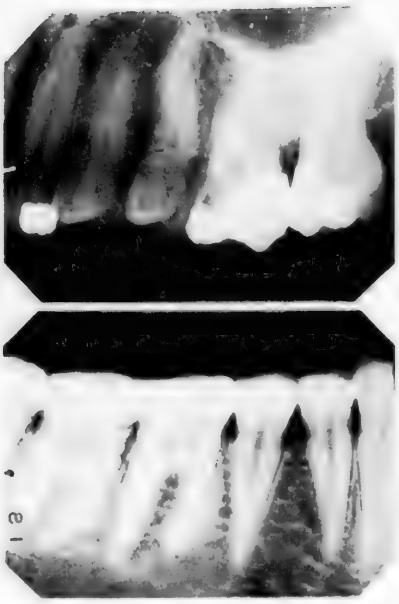

FIG. 12. Superimposition or overlapping of structures degrades diagnostic information. (Top) Superimposition. (Bottom) Overlapping.

(continued from page 12)

The maximum possible contrast of a film is an intrinsic characteristic determined by the film manufacturing process. The contrast of the finished radiograph, like its density, is controlled by the developing time and temperature. Potential contrast is lost if the developing time is too short, solution is too cold, or solution is weak. Processing for too long a period or at too high a temperature will also degrade image contrast.

Loss of contrast can also result from other factors in the darkroom, namely white light leaks and incorrect safelighting. The film in Figure 5 was fogged by extraneous light coming into the darkroom during the processing procedure. A coin was placed on the film during the unwrapping and clipping stages to demonstrate the fogging effects. Because high-speed films are extremely sensitive to white light, all light leaks must be eliminated. Fogging similar to that seen with light leaks is caused by incorrect safelight during processing, by using outdated film, by storing the film at high temperature, or by failing to adequately protect the film from stray radiation, high humidity, or chemical contamination.

SHARPNESS

The next measure of radiographic quality is sharpness. Several factors affect image sharpness: focal-spot size; source-object-film distances; and motion during exposure. The smaller the source of radiation within the X-ray tube, the sharper and more accurate the image. Most dental X-ray machines have an inherent focal spot about 1 mm square. The finite target size produces a shadow, or penumbra; its effect on sharpness depends on the source-object-film distances. By following a few simple rules, image sharpness can be optimized.

FIG. 13. Cone cutting produces an incomplete image.

FIG. 14. Reversing the film lowers image density and produces artifacts.

Use the longest practical source-to-film distance. Use of the long-cone technique will produce the sharpest image because the penumbra is minimal. Figure 6 illustrates the reduction in penumbra when the source-to-object distance is increased with the object-to-film distance held constant.

A second rule is to place the film as close as possible to the structure being radiographed. In Figure 7, the penumbra is lessened when the film is placed close to the object. Anatomical limitations sometimes prevent the operator from placing the film close to the object. In such cases, an increase in the source-to-film distance can compensate for loss in image sharpness.

Motion during the exposure will also reduce image sharpness. The structures in the radiograph shown in Figure 8 are fuzzy and indistinct. This can occur for one of the following reasons: tube head vibration or drifting; patient movement; or film movement.

DISTORTION

The next indicator of radiographic quality is freedom from image distortion. Distortion can take any of these forms: enlargement; foreshortening or elongation; and superimposition or overlapping of structures.

Enlargement, or magnification, occurs when the film is too distant from the object being radiographed. The image is magnified (in proportion to the object-to-film distance) as seen in Figure 9.

Distortion in the form of foreshortening or elongation of structures in the finished radiograph results from improper alignment. The radiograph in

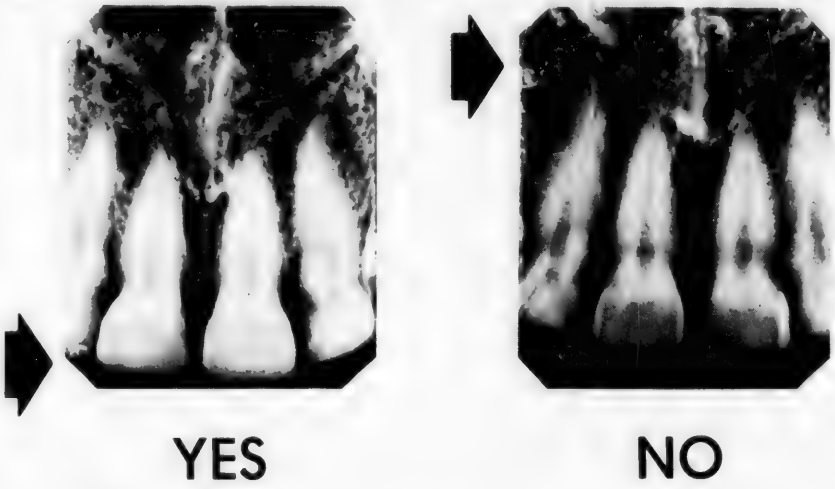

FIG. 15. Proper placement of embossed dot avoids misinterpretation.

Figure 10 shows a foreshortening of the teeth caused by excessive vertical angulation. Elongation (Fig. 11) occurs because of too little vertical angulation.

Distortion of part of the image can occur when a corner of the film is excessively bent to accommodate some anatomical contour or structure. The end result is a loss of diagnostic information. In cases where anatomical structures interfere with proper film placement, the best solution is to position the film at some distance from the structures by using cotton rolls or a film-holding device.

Superimposition and overlapping of structures are exemplified in the two radiographs in Figure 12. Superimposition of structures in the posterior maxillary projection, as shown on the left, is quite common with the use of the bisecting angle technique. The zygoma and maxillary sinus are superimposed over the root ends of the molars. Overlapping of the teeth or supporting structures results from improper horizontal angulation, as seen in the right radiograph.

ARTIFACTS

The final measure of radiographic quality is freedom from artifacts. An object on a radiograph which is not normally present, or is produced by artificial means, is defined as an artifact.[10] Most artifacts are the result of improper film placement, handling errors, or poor processing practices.

The most common artifact is cone cutting, as illustrated in Figure 13. This occurs when the beam is not properly directed at the film, leaving a portion of the film unexposed. Careful aiming and centering of the tube head in relation to the film will avoid cone cutting.

The strange pattern on the film and the loss in film density, seen in Figure 14, are undeniable evidence that the wrong side of the film was placed toward the tube head, with the lead foil backing producing an artifact.

A raised dot appears on the tube head side of a finished radiograph to aid in orienting films for mounting. The reverse of the dot (a depression) is located by a small circle on the back of the packet. When placing the film in the mouth, keep the circle toward the occlusal or incisal plane of the teeth so that the raised dot will appear in the occlusal or incisal region of the finished radiograph as seen in the left radiograph in Figure 15. Otherwise, the raised dot can obliterate information or be falsely diagnosed as pathology, as in the radiograph to the right.

FIG. 16. Wet film packets can adhere to the film emulsion.

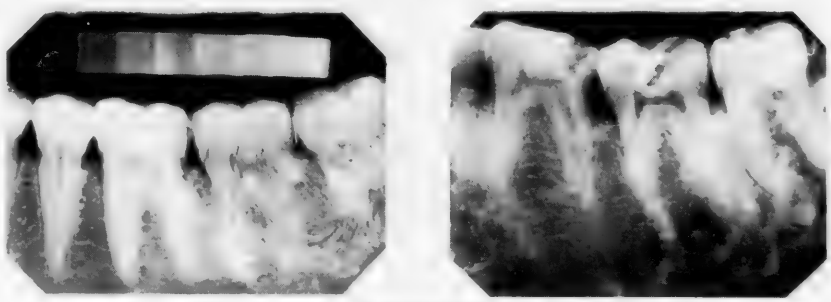

FIG. 17. Finger pressure and contaminants can degrade the image.

Paper film packets saturated with water or saliva will present problems if the paper wrapping adheres to the film emulsion. Two typical examples are seen in Figure 16. Moisture has penetrated the film emulsion and caused the black protective paper to adhere to the emulsion. The left radiograph has had part of its emulsion torn away when the wet protective packet was removed. Films should be kept as dry as possible during all procedures before unwrapping.

While the films are being unwrapped and clipped, the fingers may contact the sensitive emulsion and contaminate the film surface (Fig. 17 left). Smudges on radiograph (Fig. 17 right) were caused by chemical contaminants which contacted the film surface before developing. During film processing, an unwrapped film may be splashed with fixing solution resulting in clear spots on the finished radiograph (Fig. 18). Films must be adequately washed for at least 20 minutes to remove any chemical residue.

FIG. 18. Splashed solution or dried residue can remove portions of the image.

The foregoing artifacts are the most common ones plaguing dental practice today. There are other artifacts, but in general they are also traceable to careless practice and sloppy technique.

Dentists must produce radiographs of good diagnostic quality. The requirements are simple: (1) a basic knowledge and understanding of the principles of dental radiography, (2) adherence to recommended or proven radiographic practices, and (3) attention to

(continued on page 17)

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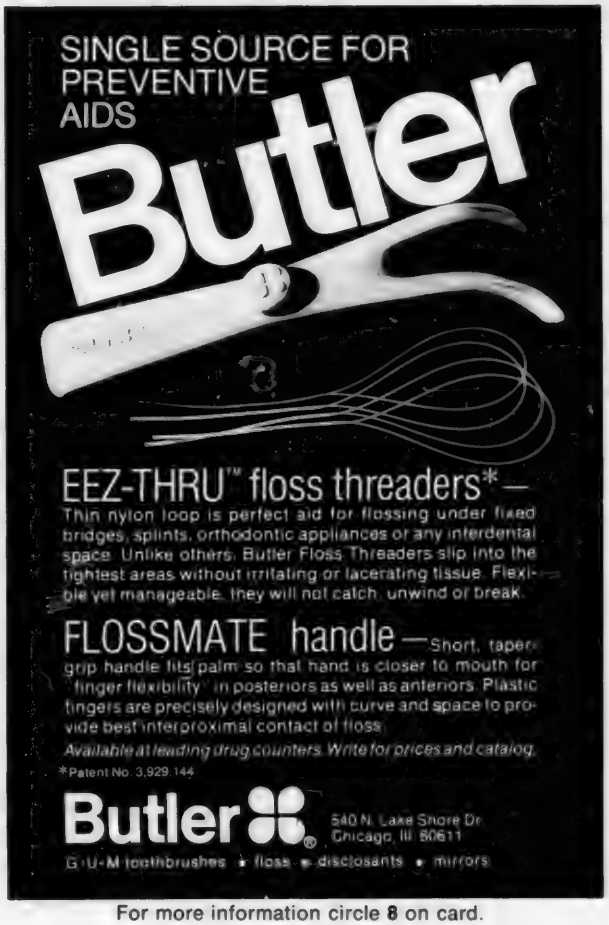
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(continued from page 15)

detail in all aspects of radiographic imaging. Each dentist must strive for maximum diagnostic information from his radiographic examinations, with the least amount of radiation exposure to his patients and his dental personnel.

ACKNOWLEDGMENT

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Automatic Film Processing

Kavas H. Thunthy, B.D.S., M.S.*

One of the most significant advances in dental radiography has been the development of automatic film processors. By their short processing time, they enable the radiology clinic to handle a greater work load without any additional personnel or space. Most automatic processors used in dentistry can process a film in from one and one-half to five minutes, whereas manual processing takes about 45 minutes to one hour. This savings in time is a boon, especially in a busy dental office. However, automatic processors also have some disadvantages. This article explains how automatic processing works and evaluates its advantages and disadvantages with respect to semi-automatic and manual processing of radiographs.

OPERATION OF AUTOMATIC PROCESSORS

The transport system of automatic processors consists of a series of rollers which carry the films from the feeding section through the developing, fixing, washing, and drying sections. In the developing tank, the exposed silver bromide crystals are converted to metallic silver; in the fixing tank, the unexposed silver bromide crystals are removed and the emulsion hardened. In the wash tank, the fixer is removed from the film emulsion. In the dryer the films are dried with warm air. In order to transport the film through the various stages of the processing cycle, the rollers are precisely spaced to avoid slipping or jamming of the films. The rollers of the transport system are driven by gears, chains, or pulleys, and any change in their speed, size, or texture alters the turning speed of the rollers and thus affects the processing time of the films.

To consistently produce the best quality radiographs, it is mandatory that the rollers transport the films through each processing section in the optimum amount of time. To accomplish this task, the constant-speed motor-driven rollers are divided into assemblies, because different stages of the processing cycle take different amounts of time. The longer the assembly, the longer the film takes to pass through a particular stage of processing. The number and type of rollers may vary from one processor to another, but the basic design is the same. When the rollers turn, they not only transport the film but also produce vigorous uniform agitation of the solutions at the surfaces of the film, thus contributing significantly to the uniformity of processing. Also, the top wet rollers in the racks and the crossover assemblies effectively remove the solutions from the surfaces of the film, reducing the amount of solution carried over from one tank to the next and thus prolonging the life of the fixer and increasing the efficiency of washing. Most of the wash water clinging to the surface of the film is removed by the squeegee rollers, making it possible to dry the processed film uniformly and rapidly.

BASIC DIFFERENCES BETWEEN AUTOMATIC AND MANUAL PROCESSING

It is fallacious to assume that automatic processing is a mechanization of hand processing. Although the basic principles of photographic chemistry are similar to those in manual processing, conventional solutions cannot be used in automatic processors without some modifications. In manual processing, when a film is immersed in the developer solution, the exposed silver halide grains are converted to metallic silver, and at the same time, the film-emulsion layer swells, softens, and becomes sticky. The fixer solution removes the undeveloped halide grains and shrinks and hardens the emulsion layer. Washing removes the last traces of processing chemicals and also produces a slight swelling of the emulsion. Drying causes the emulsion to shrink still further and lose its tackiness altogether. In manual processing these variations in film thickness are of no importance because the film does not come in contact with any other surface. However, if these variations in emulsion thicknesses and tackiness were to occur in automatic processing, the films could become slippery or too sticky or even wrap around a roller. Also, if the emulsion became too soft, it could be damaged by the rollers. With the advent of automatic processors, film manufacturers had to be very precise and consistent in making films which have the right amount of thickness and the minimum amount of stickiness to prevent film jamming.

Manual processing solutions are not adaptable to automatic processors because of the following five chemical differences between manual and automatic processing solutions. (1) Automatic processing solutions are more concentrated to shorten the processing time. (2) The processing temperature is increased in automatic processing in order to speed up processing. Since these high temperatures are liable to produce chemical fog on the film, antifogging agents like aldehydes are added to the developer. (3) To prevent softening and sticking to the rollers, special hardening chemicals are added to the developer in automatic processing. Too much hardener in the solution will harden the emulsion too quickly and prevent the developer from penetrating the film emulsion sufficiently; on the other hand, too little hardener in the solution will slow the hardening process and create film transportation difficulties. (4) To minimize swelling of the emulsion during the course of the processing cycle, compounds such as sulfates are added to the developer in automatic processing. (5) In order to maintain the proper alkalinity of the developer and acidity of the fixer, as well as the chemical strength of both solutions, a precise rate of replenishment is a necessity in automatic processing.

DISADVANTAGES OF AND PROBLEMS WITH AUTOMATIC PROCESSORS

Although the construction of automatic processors might appear to be simple, in reality the manufacturers of the first automatic processors were plagued by many problems. For instance, in automatic processing, there has to be a coordination between

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the transport mechanism, processing chemicals, temperature control, and film characteristics. This coordination has to be maintained during the complete time the automatic processor is in use. Manufacturers did not easily find solutions to such problems; however, they now have solved most of these early problems so that with proper maintenance, radiographs of consistent quality can be obtained.

Automatic processors still have certain weak points. Because of the various factors involved in speeding up the processing cycle, the resultant radiographic image–though clinically acceptable–may not be of high quality. For instance, the high temperatures used in automatic processors can produce film fog. Another major disadvantage of automatic processors is that they require regular cleaning and maintenance. Unfortunately, simple as it may sound, this is the most common cause for breakdown of automatic processors. Furthermore, while manual processing allows an opportunity to compensate for improper film exposure by changing the processing time, this cannot be done in automatic processing. Another minor problem is that intraoral films whose corners had been bent must be straightened out and inserted into the automatic processors with the unbent end first to avoid jamming the machine. Lastly, the cost of automatic processors is much more than that of manual processing tanks.

Advantages of Automatic Processors

The main advantage of automatic processors is that they save a great deal of time in processing a film. Also, accessories like film hangers and the huge dryers required in manual processing are eliminated by using automatic processors. In manual processing, solution drips occur, especially when films are read wet before completion of the fixing process; with automatic processors, this too is eliminated. Lastly, use of daylight film loaders (light filters) is possible only with automatic processors.

FACTORS TO CONSIDER IN CHOOSING AN AUTOMATIC PROCESSOR

There are many factors to consider in buying an automatic processor. First, what film sizes can be processed in the automatic processors? Some processors can handle only intraoral films, whereas others can handle panoramic and larger films. On the other hand, intraoral films cannot be processed satisfactorily in medical automatic processors made to handle large films. With the increasing use of panoramic and other extraoral radiographs, most dental automatic processors are now constructed to process films of widths up to either five inches or 10 inches as well as intraoral films.

Secondly, is the processor fully or only semi-automatic? Some automatic processors are fully automatic, that is, the processing solutions are replenished automatically as the film passes the entrance assembly. On the other hand, the semi-automatic nonreplenishing processors require solutions to be changed after a number of films are processed. If the processor is semi-automatic, what is the volume capacity of the developer and fixer compartmental tanks? Such questions as these must be asked to determine whether a processor is capable of handling a particular workload.

Thirdly, does the processor produce a dry film? At present, most of the processors produce a dry film (that is, they have a dry-to-dry cycle). However, this was not always the case–some of the older processors produce a wet film, that is, they have a dry-to-wet cycle.

Fourthly, does the processor have a variable processing time or is it fixed for a set time? Automatic processors with variable time controls allow the operator to adjust the processing speed, the advantage of this control is that you can speed processing, but the simultaneous increase in temperature of the processing solutions increases film fogging.

Lastly, what are the cost and reliability of a particular automatic processor? There is a wide range of prices and features of various automatic processors, and these must be weighed and compared carefully in selecting a machine. Another consideration is the dependability of a particular model and the local service capability of the supplier. How fast can a broken processor be repaired, and if such repair takes a long time, is there a loaner or second machine to process the radiographs? All of these factors must be considered in choosing a suitable automatic processor.

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Preventive Care and Maintenance of the Automatic Dental Film Processor

A. Peter Fortier, B.S. (Physics), D.D.S., M. Ed.*

Doctor, have you invested in an automatic dental film processor only to find that the results are not what you had expected? It is my experience in working with automatic processors for the past 6 years that there are many factors to be considered in order to get the best results. The following will be a discussion of the factors that are most critical in order to obtain high quality radiographs from the automatic processor.

Most of this information comes from practical experience with the medical x-omat and various automatic dental film processors at Louisiana State University School of Dentistry and in private dental offices in this area. Besides working with 14 processors of various makes at the school of dentistry, we also have frequent discussions with colleagues from other schools as well as with dental manufacturers and suppliers. From this experience it was found that the major problems are usually a result of inexperience or neglect of the operator rather than the processor.

Although the manufacturer furnishes instructions on the proper operation, care, maintenance and cleaning, often these detailed instructions are overlooked or not understood by the operator, and problems develop as a result. Therefore, when buying an automatic processor, it is not only important to read the specifications and instructions but advisable to post them on the wall near the processor for easy reference. Additionally, it is important for the dentist to have the dealer fully explain and demonstrate the operation and maintenance of the processor. Each person who is assigned to work the processor should be taught how to operate the equipment by one who is qualified to do so. In some instances the new dental assistant is given a quick demonstration, or none at all, and then left on her own with hopes for the best.

Automatic dental film processors require constant daily care, and preventive maintenance is essential to produce a good-quality radiograph. Automatic processors require extra know-how, since they not only involve chemical activity and proper temperature control but also electrical motors, gears, belts, shafts, rollers, pulleys, bearings, heaters, thermostats, pumps, *etc*. In other words, the processor is a combination of various systems–mechanical, electrical, and fluid. The mechanical system must be maintained, oiled, and protected from wear and corrosion. The electrical system must be well-insulated and protected from chemical and mechanical damage. The fluid system must be kept free of contamination and the solutions must be replenished regularly. Because of this, one can readily understand the necessity for extra-diligent, continuous care and maintenance of these processors.

Based on experience with the processor, an important list of do's and don'ts has been developed. If these recommendations are adhered to, most of the problems will be prevented. The following is a list of *Do's*.

1. *Keep processors clean, especially the rollers*. (This should be done according to manufacturer's instructions.) How often the processor needs to be cleaned is usually governed by the work load, which will vary with the individual office. It is recommended that all roller racks be cleaned weekly with warm running water. Every month the developer section should be soaked in special developer cleaner. The fixer section is soaked in warm water only; the same for the wash section. (Some recommend a diluted solution of bleach for the wash section only.) The cleaning procedures that are recommended are not complicated and are easy to follow; however, cleaning (especially cleaning of the rollers) should be done by one who knows how to do a thorough job. Failure to properly clean the developer section will result in contamination of the developer rollers, and there will be roller marks, streaks, foggy films, *etc*. In the fixer section, crystals will form on the rollers and the emulsion will not be properly hardened. This will cause the film to slow up or stick in the transport section. The water section will become stagnant, allowing algae to grow and form a thick film on the surface. This will cause spots and artifacts on the films. The tanks should be thoroughly rinsed and wiped out with a lint-free cloth.

2. *Maintain proper solution levels*. When the levels are low, the time each film is immersed in the developer and fixer is shortened, which will result in underprocessing the film.

3. *Replenish solutions according to use*. The solution should be replenished in order to maintain proper chemical strength. Contaminated and exhausted solutions will produce a smudgy, gray, foggy-looking film.

4. *Check the temperature of the developer and incoming water frequently*. Changes in the developing temperature result in a change in film density. The lower the temperature, the lighter the film. Changes of one or two degrees in temperature are noticeable in the final product. This is why it is important to have an accurate thermostat to control the temperature of the solution. The different tanks in most processers are insulated from each other so that the temperature in one tank will not effect the others. Filters are needed on the incoming water to remove impurities, and the filter must be checked for clogging.

5. *Align transport sections after cleaning*. On replacing the transport sections after cleaning, check to be sure sections are properly seated in position and in correct alignment. If they are not aligned properly, the film will not follow through and it will usually end up in the bottom of the tank.

6. *Keep cover open when not in use*. Lift cover and leave slightly open after each day so that chemical

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fumes can escape. This will prevent contamination of the solutions.

7. *Remove the lead backing and paper from the film before placing in processor*. The paper from the film packet is sometimes accidentally dropped in the feed slot causing a jam in the machine.

8. *Lubricate moving parts regularly*. Gears, bearings and drive mechanisms must be oiled and the belts should be checked each time processor is cleaned. Failure to lubricate the drive system will result in excessive wear and a slowing up of the processing time causing a loss in film quality.

9. *Feed film straight in*. When processing film, mainly the larger extra-oral film, be sure to place film straight in line with the roller system; otherwise it might bend along the sides and jam up.

The following is a list of *don'ts*.

1. *Don't put bent film in processor unless it can be straightened out*. If only one end is bent, try to straighten it, but put the opposite unbent end in first. All processors will have trouble with bent film, depending on how much the film is bent. There is one company that advertises that their processor will take bent film. It didn't work for us.

2. *Don't put wet or damp film in the processor*. This will contaminate the rollers and solutions.

3. *Don't feed film in too quickly or too closely together in the same feed slot*. If you do, they may bunch up and overlap each other.

4. *Don't splash or drop fixer in the developer*. A very small amount of fixer will contaminate the developer.

5. *Don't try to fix serious problems yourself*. When problems exist that you don't understand or can't solve, call in a qualified serviceman.

There are various types of automatic dental processors available today, and new ones are continually appearing on the market. All of the processors require chemicals that are designed specifically for them. Most of them use the roller transport system, while others use tracks, racks, clips, *etc*. Some special features are available for the processor, such as the daylight loader which eliminates the need for a darkroom. Some have automatic replenishing systems that will replenish themselves as each film is processed. One should consider the size of the solution tanks, since the smaller-volume tanks will be affected more readily by chemical and temperature changes and will require more frequent solution changing. If the larger 8 × 10 or panoramic films are used, it is advisable to have a replenishing system for the processor. This will save time and money, because it is easy to forget to replenish the solutions manually.

There is no change in the regular exposure factor or technique when developing with the automatic processor. Comparisons have been made by using double film packets, one developed in the automatic processor and the other in the manual tank using regular solutions, with no significant differences. This is a good method for checking one against the other. Furthermore, with automatic processing there is less chance of patient overexposure because the operator can't sight develop and shortstop this developing process. This is an advantage, because if the film is overexposed it will be too dark, and if it is underexposed it will be too light; thus the x-ray technician is forced to adjust the x-ray machine to the proper output.

For the dentist who doesn't have a daily need for taking radiographs, the advantages of an automatic processor may not outweigh the disadvantages because of the increased care, maintenance, and expense. Even the solutions are more expensive (about twice) than those used in regular manual processing, and they have to be changed more often. Furthermore, when purchasing a processor, one should find a dealer (preferably local) who has a good repair department and qualified servicemen who can service the equipment when needed.

In conclusion, we feel that about 80 or 90% of poor film quality is due to unclean or improperly cleaned processors, failure to keep fresh solutions at the proper levels, and improper procedures such as feeding in film too fast, too close, or bent. By following the above suggestions, the dentist and his staff can prevent many problems and obtain consistently high-quality dry radiographs.

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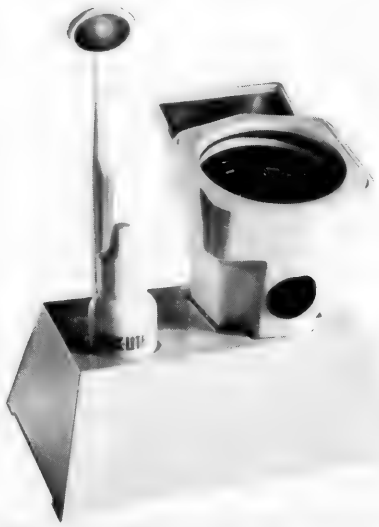

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Histologic-radiographic Relation of Proximal Surface Carious Lesions

Robert E. Buchholz, D.D.S., M.S.*

Every practitioner of dentistry has faced the question of relating the radiographic image of proximal surface dental caries to the actual penetration of that lesion (Fig. 1). The speculated relationship is an important factor in the treatment plan rational for that lesion. F. W. Hinds[2] reported a study in 1943 which established that the actual penetration of the proximal surface carious lesion was greater than its radiographic image indicated. Two other results of the same study are often forgotten, though equally important. One, the dentin was already cariously involved in every instance the slightest radiographic image of the lesion was observable under the most ideal visualizing conditions. Second, with radiographic evidence of the lesion and the dentin involved, many teeth had smooth, apparently intact surface enamel over the lesion, probably a process of temporary remineralization. A recent study by R. W. Owen[4] confirmed the findings of F. W. Hinds in general and refined the pathologic-radiographic penetration relationship† of proximal surface lesions to a specific range of 1.5–2.8 when discoloration of the dentin is used as the guide to caries penetration.

The important unanswered question for the practitioner still remains: how much more penetrating is the dentin degeneration than the radiographic image implies? The question is most pertinent when the radiographic image of the proximal surface carious lesion appears confined to the enamel. Treatment planning by the conscientious practitioner is greatly influenced by that information when available, or its speculation when not available.

A pilot study was designed to determine if there was a mathematical ratio between the depth of penetration of a proximal surface carious lesion and its radiographic image when the image was apparently confined to the enamel. A related question of interest to the practitioner was of possible relation of that ratio to the patient's age. It had been noted that the patient's age was often considered a factor in treatment planning carious lesions.

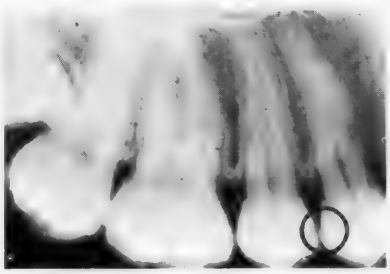

FIG. 1. Radiograph showing evidence of proximal caries on the distal surface of the first bicuspid.

PROCEDURE

All sample teeth selected met three requirements: (1) they were to be extracted for some reason other than deep caries, (2) the radiograph indicated a proximal surface carious lesion, and (3) the radiographic image of that lesion appeared confined to the enamel.

FIG. 2. Photomicrograph at 6.4X of the lesion demonstrated radiographically in Figure 1.

The radiographs were those exposed as a part of the patient's complete oral examination provided by the Department of Oral Diagnosis of the College of Dentistry, State University of Iowa. Periapical radiographs were exposed by means of a paralleling long cone technic. Exposure factors were 65 kVp, 10 mA, and exposure time as recommended by the film manufacturer. All processing was done according to manufacturer's recommendations. The processed and mounted radiographs were visualized on a masked view box in a semidark room with the aid of a 3X hand magnifying glass.[1] Those teeth selected were recovered immediately following extraction, cleaned of blood with soap and water, and completely imbedded in self-curing clear Bioplast plastic blocks. The imbedded teeth were then thinly sliced on the plane of their long axis from mesial to distal through the proximal carious lesions to a thickness of 80 microns by means of the Bronwill Thin Slicing Machine. The unstained, undecalcified sections were mounted on glass slides in preparation for observation with the optical microscope. At 6.4 × magnification, the lesion was contained within one field permitting photomicrography of the entire lesion on one exposure (Fig. 2). The photomicrograph was projected onto paper and a tracing made with special attention to the zones of dental caries (Fig. 3).[3] The sclerotic dentin zone, the hypercalcified defense mechanism against the lesion was considered outside the lesion and the penetration limit of the lesion.

To facilitate accuracy of measurement, both the radiograph and photomicrograph were magnified proportionally. The penetration of the lesions image on the radiograph was measured as was the histologic penetration as seen by means of the photomicrograph (Fig. 3). The measurement of the penetration seen by means of the

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† Penetration relationship

$$= \frac{\text{Caries penetration determined by color}}{\text{Radiographic penetration}}$$

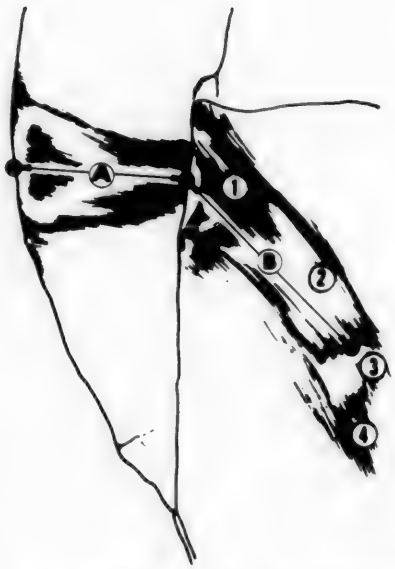

FIG. 3. Tracing made from the projected image of the photomicrograph of Figure 2. A–measurement line of penetration through the center of the lesion in the enamel: B–measurement line of penetration of the lesion in the dentin: A + B–measurement of the lesions total penetration. Indicated zones of dental caries of dentin: 1–complete decalcified zone; 2–partial decalcified zone: 3–sclerotic dentin (defense mechanism); 4–protective metamorphosis.

photomicrograph was then divided by the measurement of penetration seen on the radiograph, the result being the "penetration factor," or that mathematical ratio between the actual penetration of the lesion and its radiographic image.

$$\text{Penetration factor} = \frac{\text{Histologic penetration}}{\text{Radiographic penetration}}$$

RESULTS

The data indicates there is a mathematic relationship between the histologic evidence of a proximal surface carious lesion and its radiographic image. The average and mean of the penetration factors of the 64 samples was 3.0, with a range from 2.3 to 3.6 (Table 1). No pattern specific to age was observed. In every sample, the finding of F. W. Hinds were re-established.

Table 1.

Penetration Factor	Patient's Age In Years							Total
	10–14	15–24	25–34	35–44	45–54	55–64	65–74	
3.6–		1					1	2
3.5–	2	1	1	1				5
3.4–	1	2			1	1		6
3.3–	3	1		1	1			6
3.2–		1		3	2	2		8
3.1–				4		1		5
3.0–	2		2		1		1	6
2.9–	3		2		1	1		7
2.8–	1		3		1	1		6
2.7–	3		4					7
2.6–					2	1		3
2.5–	1	1						2
2.4–								1
2.3–		1						

DISCUSSION

When the radiograph demonstrated the smallest perceptable indication of a proximal surface carious lesion, the histologic examination showed extensive demineralization in the dentin. It is, therefore, apparent that lesions which can be detected radiographically under the most ideal viewing conditions have actually invaded the dentin and cannot be considered incipient. The frequently considered patient age factor in treatment planning seemingly has no foundation in fact. An average penetration factor of 3.0 can be a useful guide in the treatment planning of those lesions having a radiographic image confined to the enamel when taken with other pertinent factors peculiar to the individual patient.

It is hoped that further, more refined study will be done on the question providing more information for the advantage of the practitioner.

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Research Annotation of the Effect of Urea Peroxide Solution on Dental Plaque

J. H. Manhold, M.A., D.M.D.* and E. A. Manhold, B.S.**

Dental plaque today is perhaps the most strongly implicated cause of dental caries and periodontal disease. Thus, the most recent investigative thrusts have bveen toward inhibition or destruction of this material. One thought is that antimicrobial products, such as are available in self-applicable forms to relieve occasional oral inflammations, might help reduce dental plaque accumulations if used instead in a rational program.

For long term use, such products should be harmless in oral tissues and unlikely to result in the development of resistant microbial strains. Hydrogen peroxide and urea peroxide, which release hydrogen peroxide upon solution in water, are two which meet these criteria and urea peroxide tends to solubilize organic dental deposits as well through the effects of urea.

With respect to hydrogen peroxide, it is a moderately potent antibacterial compound. Concentrations less than 0.01% in liquid medium are inhibitory to the growth even of active catalase producers[13] and commercial solutions (3%) pass the disinfectant test of killing *Staphylococcus aureus* cultures in five minutes,[17] as well as various Gram negative bacteria, including fusiform bacilli of the mouth.[9] In addition, hydrogen peroxide is part of the normal mechanisms of the body which destroy bacteria. The lactoperoxidase of saliva reacts with peroxide and iodide, and the myeloperoxidase of the neutrophiles reacts with peroxide and halides to cause halogenation of proteins and death of bacteria.[8] And, it is unlikely that bacteria will start to develop resistance to a normal, universal immune process.

With respect to urea peroxide, this product, when dissolved in glycerine or propylene glycol and applied to the margins and sulci of inflammed or infected gingiva, was demonstrated to bubble continuously for up to 25 minutes.[4] It, therefore, is active *in vivo* for a sufficiently long time to kill bacteria, in addition to removing food or plaque by mechanical dispersion and foaming.

Therefore, from a very practical viewpoint, let us look at the advantages of these two substances. Since hydrogen peroxide is a normal body metabolite generated by the neutrophils to kill bacteria, the body is equipped to destroy an excess and to avoid harm. Urea peroxide in solutions from 4 to 15% in glycerol or in propylene glycerol have been used as antibacterials in treatment of infections of inflammations of the eye, ear, mouth, skin and anorectal area, with no damage to the tissues over weeks to months of frequent applications.[1–4,7,16] A decrease in the time necessary for healing also has been claimed in many of these applications and has been demonstrated by the senior author in both animals and human subjects.[10–12]

It was decided therefore, to test a product, now in the commercial development stage,* which contains 15% urea peroxide in propylene glycol, after safety trials had shown that twice-daily applications produced some plaque control.[18] The frequency of application was increased to four times daily in our investigation, once after each meal, and once before bedtime because the bacterial population of the mouth varies with the time of day, decreases with tooth-brushing, and generally increases after meals and during the night.[14] It was thought that the foaming action of the product after a meal would reduce food residues in the mouth, in addition to killing bacteria and that frequent application would compensate for a relatively short period of product activity in reducing plaque extent.

Table 1. The Effects of Urea Peroxide, U, and Placebo, P, on Plaque Scores in each Jaw, Maxillary and Mandibular.

Jaw	Treatment	Before	After	Difference	Difference	t
Maxillary	U	8.273	5.182	−3.091		
					.818	1
	P	8.455	6.182	−2.273		
Mandibular	U	10.273	6.818	−3.455		
					2.728	3.70*
	P	6.818	6.091	−.727		
Whole Mouth	U	9.273	6.000	−3.273		
					1.773	2.70*
	P	7.636	6.136	−1.500		

* Difference is significant at $\alpha < .01$.

MATERIALS AND METHODS

Twenty-five subjects free of oral disease and any possible complicating systemic conditions had their plaque rated on the 6 upper and lower anterior teeth using erythrosine as the disclosing agent and the Podshadley Method of rating plaque.[15] The group included 20 male and 5 female dental students with a mean age of 25.76 (±3.47) years. After the plaque was rated, a second investigator assigned each subject in a random manner to use either a placebo or a 15% urea peroxide solution in propylene glycerol.** Application of the solution was

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Table 2. ANOVA Using the Difference Between Before and After as the Variate of Cross-over Design as Described by Cochran and Cox[5]

Source	d.f.	Sum of Squares	Mean Square	F
Treatments	1	176.000	176.000	7.20*
Orders	1	11.000	11.000	<1
Replications	21	786.909	37.472	1.53
Error	20	489.000	24.450	

* Difference is significant at 97.5% confidence level.

made by the subject himself four times a day for four days at the lingual and buccal gingival crevice line through an applicator (a tube-like device attached to the solution bottle) and maintained the solution in place for one minute by the clock. All subjects were instructed to continue their habitual oral hygiene, but to avoid any medications. On the fifth day, a second plaque score was recorded by the first investigator.

There was then a one week "rest period" after which a cross-over was made in treatment and the same before and after examinations were made.

A total of 22 subjects completed the study as one complained of irritation with use of the urea peroxide solution, one complained of irritation with the placebo and one complained of irritation with both solutions. All others completed all treatments.

RESULTS

The effects of urea peroxide, U, and placebo, P, on plaque scores in each jaw, maxillary and mandibular, is shown in Table 1. The effects of the urea peroxide treatment were more pronounced in the mandibular jaw. This may be due to a tendency for liquids to pool in the lower lingual region of the mouth. The effect of the urea peroxide treatment on plaque reduction is significant in the lower jaw as well as in the whole mouth. The statistical significance of these results is further verified by analysis of variance, ANOVA. Table 2 is the ANOVA using the difference between before and after as the variate of cross-over design, *e.g.*, as described by Cochran and Cox.[5] The difference between urea peroxide and placebo "Treatments," is significant at the 97.5% confidence level.

CONCLUSION

From these data it appears that this urea peroxide solution is effective in reducing plaque area scores.

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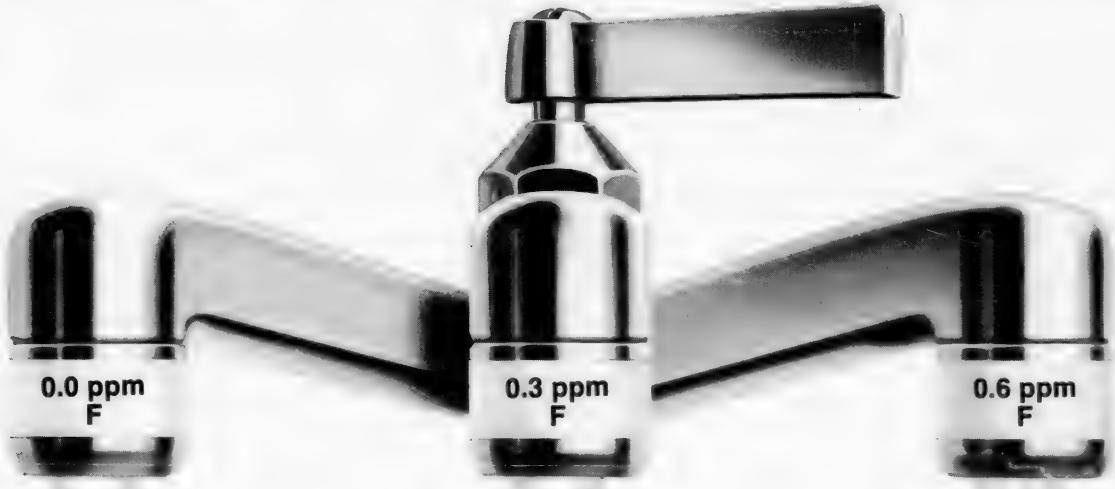

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*Some dental authorities now recommend 0.25 mg. F daily under age 2.

[1]*Accepted Dental Therapeutics:* 241, 1973-1974. [2]Aasenden, R., and Peebles, T.C.: Effects of Fluoride Supplementation from Birth on Human Deciduous and Permanent Teeth, *Archs Oral Biol* 19:321, 1974. [3]Mellberg, J.R., Nicholson, C.R., and Law, F.E.: Fluoride Concentrations in Deciduous Tooth Enamel of Children Chewing Sodium Fluoride Tablets, *J. Dent Res* 51:551, 1972.

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Reduction of Baseline Gingivitis Scores With Repeated Prophylaxes

Kristin Talbott, D.H., M.D.H., Irwin D. Mandel, D.D.S., and Neal W. Chilton, D.D.S., M.P.H.

Several recent studies have demonstrated that regularly repeated professional prophylaxes, when combined with toothbrush instruction, result in the establishment and maintenance of healthy gingival tissues with minimum evidence of gingivitis[2,4] in school children, and a retardation in the rate and progression of marginal periodontitis[6,8,9] in adults. Using prophylaxis alone (no formal attempt at plaque control instruction), Suomi *et al.* showed there is a smaller increase in gingivitis over the three year period as the frequency of prophylaxes increases from one to three per year.[10] Increasing the frequency of oral prophylaxes to two week intervals has been reported to markedly improve the gingival state,[3] prevent the obvious signs of gingival inflammation,[1] and maintain a satisfactory level of oral hygiene.[7]

At the present time, there is great activity in clinical trials to determine the effectiveness of various types of agents for the prevention and/or reduction of plaque and gingivitis. In order to evaluate the effect of chemical agents used as adjuncts to toothbrushing in reducing the rate and degree of gingivitis, it is usually necessary to reduce the level of gingival inflammation in a subject population within a short period of time, *without* changing their oral hygiene habits. If intensive oral hygiene instruction is instituted, the effect of this greatly improved oral hygiene can quite readily vitiate the clinical effect of the mouth rinse. This is particularly true if the basic effect of the mouth rinse (or other antiplaque and antigingivitis agent) is of a positive but modest order. A series of complete oral prophylaxes, *without* oral hygiene instruction, would appear to be a preferable alternative.

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Table 1. Average Gingivitis Scores per Tooth before and after Four Weekly Prophylaxes, without Altering Oral Hygiene Practices*

		Before		After		Difference	
Examiner	No. Subj.	Mean	S.D.	Mean	S.D.	(Bef-After)	S.D.
1	21	9.97	2.468	3.97	0.995	6.01	2.310
2	20	9.98	2.485	3.57	1.539	6.41	1.894
3	23	8.57	2.486	3.43	1.473	5.15	2.491

* A per-surface score can be derived by dividing the respective tooth scores by 6.

MATERIALS AND METHODS

Sixty-six subjects were selected on a volunteer basis from the junior and senior classes at Columia University School of Dental and Oral Surgery. The subjects were randomly divided into three groups, providing an equal number for each of the three investigators. Each subject was examined and initial plaque and gingival indices were recorded. Plaque was recorded using the modified Quigley-Hein index[11] on the four first molars, the maxillary right central incisor and the mandibular left central incisor. Gingivitis was recorded using the modified Löe and Sillness index[5] on all teeth, excluding third molars. For both indices, each tooth was divided into six areas, three buccal and three lingual, using the mesial and distal line angles as the dividing lines. Following the initial indices, each subject was assigned appointments for four prophylaxes performed at weekly intervals.

The first and some of the second prophylaxes were done by graduate hygienists. Some of the second and all of the third and fourth prophylaxes were done by both graduate and student hygienists. Subjects were assigned to graduate or student hygienists depending on patient difficulty and hygienist availability. The two supervisors were responsible for making the assignments and recording the completed prophylaxes.

When the subjects inquired about oral hygiene instructions, they were asked to maintain their normal oral hygiene procedures.

RESULTS

Sixty-four subjects completed the regimen of four weekly prophylaxes. Their gingivitis scores, on a per tooth basis, before and after the four prophylaxes, appear in Table 1, classified by examiner. The average difference between the preprophy and after four prophy gingivitis scores, for all 64 subjects, was 5.83 per tooth, with a standard deviation of 2.87. This average difference was statistically significant ($t = 20.4$; $p < .001$).

DISCUSSION

The data from this study show that the average gingivitis score per tooth can be reduced from 9.48–3.65 (which

is significant, both clinically and statistically), without altering the usual oral hygiene practices of the subjects. Other routines for reducing gingivitis scores as low as possible, have utilized improved brushing and other techniques for improving oral hygiene. This improved oral hygiene could then carry over to the actual clinical trial. If the antigingivitis (or antiplaque) agent being studied is of moderate effectiveness, the improved oral hygiene will vitiate the possible effect of the trial agent. If repeated prophylaxes alone are employed to reduce the scores, leaving the oral hygiene practices alone, then the effect of the test agent can be demonstrated.

SUMMARY

A weekly prophylaxis was performed on 64 dental students over a four week period, reducing the average gingivitis score per tooth from 9.48–3.65. This difference is both clinically and statistically significant.

The gingivitis score can be reduced without changing oral hygiene habits, thereby allowing for a subsequent clinical trial of an antigingivitis or an antiplaque agent of modest effectiveness without being "washed out" by the effect of improved oral hygiene.

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This paper concludes the Symposium on Dental Fluorides, Dr. Frederick M. Parkins, Guest Editor, which started in the January-February 1977 issue of The *Journal of Preventive Dentistry*.

Prescribing Low Potency Fluorides for Frequent Use

Frederick M. Parkins, D.D.S., M.S.D., Ph.D.*

A variety of fluoride-containing preparations are available for administration on a daily to weekly basis. This usage of products with lower fluoride concentrations results in a repetitive exposure of the oral tissues to fluoride. The frequent exposure to low levels of fluoride is a direct contrast to the annual or semiannual topical application of preparations containing concentrations of fluorides in the range of 1.2 to 2.5 per cent. The caries reductions through ingestion of different types of lower concentration fluoride products vary, but these fluorides are significantly effective, when used according to directions, in reducing disease at a favorable cost-benefit relationship.

Frequently available fluorides provide unique therapeutic possibilities which are unattainable with infrequent fluoride applications.[9,35] Enamel surface changes occur constantly and may alter the residual effects from an annual or semiannual topical fluoride application. Fluoride, which is available during or soon after enamel changes take place, may be especially effective in reducing the breakdown of these areas. The maintenance of a fluoride blood level for systemic benefits requires repetitive fluoride intake. Frequent fluoride ingestion is necessary to sustain a circulating fluoride level in the blood and provide bioavailable fluoride for incorporation into developing tooth structure. Oral microorganisms are directly affected by the fluoride concentrations of the frequently used preparations. Plaque also accumulates fluoride in amounts which are potentially high enough to have an effect on the adjacent enamel surface and the plaque microorganisms. For fluoride to inhibit microorganisms and to become bound into plaque deposits it must be repeatedly present in the oral cavity.

Various fluoride products of lower concentration for frequent administration will be reviewed by categories. Their efficacy will be discussed in conjunction with recommendations for programs of administration.

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ENAMEL MOTTLING (FLUOROSIS)

The medical safety of fluorides is observed best in the satisfactory daily use of large fluoride doses for bone diseases as discussed by Dr. Spencer in her accompanying paper in this symposium. The disfigurement of mottled enamel can occur during tooth formation at fluoride levels which are otherwise ingestible without other side effects.

The action of fluoride on dental caries is well documented. Studies concerning the effect of fluoride on the process of enamel formation have not been definitive. Incidental observations of mottled enamel following the use of fluoride supplements have been reported[1,27–29,32,45] in conjunction with studies on the prevention of caries. Recording of the incidence and severity of mottling has shown questionable to very mild mottling in up to 67 per cent of those examined.

Neither the cause nor the frequency are precisely known.

The occurance of mottled enamel is now being noted on permanent incisors of children receiving supplemental fluorides since birth. The term "snow capping" is being applied to numerous white opacities seen in the enamel surface, especially the incisal one-third. The condition resembles the degree of 0.2 to 1.0 in Dean's index for fluorosis.[14,15] While not disfiguring to most observers, close examination reveals an abnormal appearance. Hennon[27,28] observed the occurance of mottling in children receiving 0.5 mg F since birth in communities with suboptimal fluoridation (0.6–0.8 ppm). The incidence was comparable to that reported for similar studies in nonfluoridated areas. This finding may be due to nursing or extensive use of commercially prepared foods for infants. The total fluoride intake, either with or without fluoride supplements, may be similar for infants in most communities and independent of the fluoride in the water supply because of the extensive use of prepared foods.

In Switzerland some years ago the recommended daily dosage for infants was reduced from 0.5 mg to 0.25 mg because of mottled enamel being observed on erupting incisors. Clinical observations of children who received the lowered dosage have not revealed the continued occurance of mottled enamel.[33]

TYPES OF FLUORIDE SUPPLEMENTS

The most common type of frequent and low level fluoride source is the fluoridated water supply. Everyone in the community is exposed through the drinking water and many other water related sources. Reductions of caries incidence of 50 to 70 per cent are obtained.[3–5,17,34,41] Tablets containing fluoride alone or in combination with vitamins are an alternate daily vehicle. Mouthwashes which are swished and swallowed are additional fluoride products. Concentrated liquids containing fluoride for infants are available. Dentifrices and mouthwashes, with fluoride as an ingredient, which are not swallowed, are also used. They provide a fluoride source for enamel surfaces and plaque, but since they are not ingested they contribute little fluoride to the circulating blood.

Fluoride Tablets

Tablets containing sodium fluoride (NaF) are commercially available in potencies of 1.0 mg, 0.5 mg, and 0.25 mg fluoride. Studies have shown that salivary fluoride concentrations approaching 200 ppm are obtained intraorally with the chewing of 1.0 mg NaF tablets.[42,43] When these tablets are ingested on a daily basis, children in fluoride deficient communities exhibit reductions of 25 to 70 per cent in the incidence of dental caries.[12,19,44] Youngsters starting the use of chewable fluoride tablets at early preschool ages, presumably before the processes of enamel decay have had an opportunity to extensively affect enamel surfaces, appear to receive the greater reductions.

The incorporation of phosphate and acid producing ingredients to comprise acidulated phosphate fluoride (APF) has created a separate group of tablets containing similar fluoride amounts. Most tablets, both of the NaF and APF types, available at present are of the chewable type. The APF concept of increasing fluoride incorporation[7] into enamel appears valid for topical solutions and gels which are held directly against enamel surfaces. When mixed with saliva, as with rinses and chewable tablets, the additive value of the acid and phosphate has not been substantiated. The acid flavor elicits increased salivary flow which reduces the intraoral fluoride concentrations.[43] Increases in enamal fluoride levels observed with APF products above those found with NaF vehicles have not been demonstrated. Clinical results for APF preparations of low potency and frequent use have not shown superiority over neutral sodium fluoride products. Since the cost of APF preparations is higher, their prescription is best limited to those types of products where neutral sodium fluoride substitutes are not readily available.

Fluoride—Vitamin Tablets

For convenience fluoride dosages have been combined with the recommended daily dose of multi-vitamins. The presently available products contain 0.5 mg and 1.0 mg amounts of fluoride. The tablets with both vitamins and fluorides have been shown to have effects on dental caries; the results are similar to tablets containing fluoride alone.[30] The combined products may be taken more reliably by patients due to the convenience and an increase in motivation. However, the dosages of all ingredi-

ents must be satisfactory. As yet, 0.25 mg fluoride tablets which contain the recommended daily vitamin dosage are not known to have been marketed. Dividing a 0.5 mg fluoride-vitamin tablet is unsatisfactory due to the reduction in vitamin dosage.

Fluoride Liquids

Liquid fluoride preparations are available which permit dropper dispensing of controlled amounts of fluoride. Usually 0.1 mg of fluoride per drop is dispensed. They may be fluoride solutions alone or in combination with vitamins. Either are considered equally effective for reducing caries incidence, since vitamins have been shown to have no separate effect on their own.[30]

Caution should be exercised in prescribing vitamin-fluoride liquids to infants. Only through administration of fluoride on alternating days with preparations containing vitamins alone in between can the recommended vitamin dosage be given with 0.5 mg fluoride containing preparations. The direct intraoral administration of these fluoride solutions is advised rather than diluting them in water, juice, or formula so the topical aspects can be maximal. They should be placed on the tongue or inside the cheek where they are not directly swallowed or aspirated.

Mouthrinses

The use of fluoride rinses has been shown to produce reductions in caries incidence of 16 to 50 per cent.[1,6,24,25,31,36,39,47,49,50] The benefits are similar with two types of administration routines. Either daily use of 0.05 per cent sodium fluoride rinses or weekly use of 0.2 per cent sodium fluoride have been found successful. Both neutral sodium fluoride and APF products are available. The flavor is important to acceptance by the patient. If one product is considered objectionable, an alternative should be prescribed.

For systemic benefits a fluoride rinse which can be swallowed should be recommended. After the eruption of second permanent molars a fluoride rinse with surface active ingredients to give the mouth a clean and fresh sensation can be substituted. At that age and beyond the two different types of rinses should be effective in reducing caries incidence at similar levels.

Dentifrices

Unsupervised use of a fluoridated dentifrice in fluoride deficient communities will lead to reductions of about 18 per cent in caries incidence.[21,26] Dentifrices are available which contain either stannous fluoride, sodium fluoride or monofluorophosphate additives. The fluoride concentration is usually 0.6 per cent. "Crest®" and "Colgate MFP®" dentifrices have been given the approval of the American Dental Association[10,11] as products of proven effectiveness in reducing the incidence of dental caries.* Other fluoride containing dentifrices which are available have not been clinically tested and shown to be effective. Caution is therefore advised in making recommendations.

Additive reductions of significant amounts have also been observed with the combined use of a fluoridated dentifrice with a topical fluoride program.[40,48] The combination of a fluoridated dentifrice with other fluoride treatments is recommended for more complete caries control.

RECOMMENDED PROGRAMS

Patients with a personal history of active caries in all communities at almost all ages will benefit from a suitable supplemental program of fluoride treatment. The program should optimally be initiated in conjunction with semiannual topical fluoride applications of a high potency fluoride preparation.

Fluoride prescriptions should be based on age and the fluoride level of the community water supply. The public health departments of most communities can be contacted for water fluoride content information. Where the fluoride concentration in the water is unknown samples can be sent to almost any dental school for analysis. Plastic containers properly labeled should be used since fluoride reacts with glass. Multiple collections on different days will avoid any possible daily variability. When the age and water fluoride content are known the fluoride dosage can be selected from the dosage table (Table 1).

Figure 1 shows the relationship of the recommended dosage for patients in a fluoride deficient area (0–0.2 ppm) to age and average body weight. A maximum of 0.05 mg of fluoride per kilogram is advised.

Specific fluoride products may not be available at local phar-

* Editor's Note: Maclean's has received ADA approval also, since preparation of this article.

Table 1. Supplemental Fluoride Dosage Schedule.

Age	Water Fluoride Content		
	0–0.3 ppm	0.3–0.7 ppm	0.7–ppm
6 mos–2 yr	0.25 mg	0	0
2–4 yr	0.50 mg	0.25 mg	0
4–6 yr	0.75 mg	0.50 mg	0.25 mg
6–8 yr	1.0 mg	0.75 mg	0.50 mg
8 yr and over	1.0 mg	1.0 mg	1.0 mg*

* Dosage increased because tooth crown formation usually complete (except for third molars).

macies. Prescriptions written by generic name (*e.g.*, sodium fluoride) could be helpful to some patients in promptly procuring the desired type of fluoride preparation.

Large amounts of fluoride can be accidentally ingested without harm. Amounts up to 1.0 gm sodium fluoride for all but the smallest infants and 2.5 to 5.0 gm for adults can be tolerated with only transient acute symptoms. However, it has been considered unwise[12] to prescribe for the dispensing at any one time of more than 264 mg sodium fluoride (120 mg fluoride).

Infants

The initiation of fluoride supplement programs for children in fluoride deficient communities is recommended as soon after 6 months of age as possible. At 6 months of age administration of a suitable fluoride-containing liquid is recommended. Administration should be directly by an intraoral drop dispensing method rather than diluting the daily dosage in water or fruit juice. The prescribed number of drops to provide the proper dosage from a bottle or medicine dropper should be placed on the tongue or in the inside of the cheek. Fluoride containing vitamin preparations in liquid form with the appropriate fluoride concentration may also be used. For dosages at various community water fluoride levels and patient ages, see Table 1.

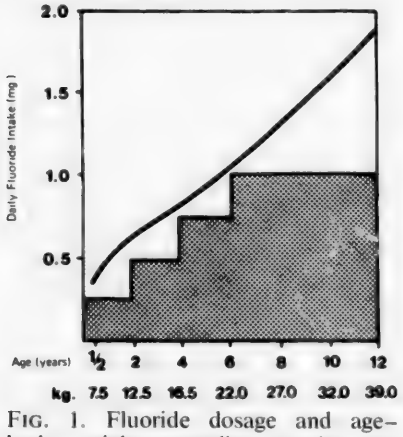

FIG. 1. Fluoride dosage and age–body weight according to the recommended daily intake. (Adopted from Zyma, Nyon, Switzerland, *Fluoride und Zahngesundheit*, 1973; p. 49.

Preschool

When old enough to accomplish their use, youngsters can be switched from infant solutions to chewable fluoride tablets or a fluoride mouthrinse which is to be swallowed. This is generally the age when a professional topical fluoride program can also be initiated. Daily administration is probably most effective. Weekly fluoride rinses of higher concentration have been found to have similar effectiveness in older school age children.[31,50] The tablet or rinse dosage employed should be related to known water fluoride concentrations and patient ages. Table 1 shows recommended daily fluoride amounts. Active oral irrigation with either rinse or chewable tablet preparations after brushing and flossing the teeth is the recommended method of administration. This is best accomplished just before bedtime. During sleep the flow of saliva is reduced and caries activity may be increased. In all cases, rinsing with non-fluoride preparations should be avoided for at least 30 minutes afterward.

It has been concluded that the use of high frequency-low potency fluorides is most effective in lowering caries incidence when administration of fluoride supplements is begun at or before the completion of eruption of the preliminary dentition.[45] Studies have shown reductions of 50 to 70 per cent under these conditions.[2,29,37,38] Significantly lower reductions in caries incidence have been observed when therapy is initiated at school age. Reductions of 30 to 40 per cent are commonly observed.[1,16,20,46] The difference in levels of reduction in caries incidence could be due to subclinical lesions already present in the older patient groups when fluoride treatment was begun or in combination with markedly reduced systemic benefits because a number of permanent teeth have fully formed crowns and may even be erupted.

Elementary School

The use of fluoridated dentifrices combined with semiannual office topical fluoride applications is recommended for all pa-

tients of this age. Where the preventive motivation is high or the patient displays active dental caries additional supplemental fluorides are advised. This age group can take advantage of supplemental fluorides with minimal risk of fluorosis because the crowns of the anterior teeth are usually already fully formed. In optimally fluoridated communities supplements are recommended for selected patients.[44]

Weekly rinses with a 0.2 per cent sodium fluoride containing preparation have been found to be similar in effect to daily rinses with 0.5 per cent sodium fluoride solutions. Both have yielded significant reductions in caries incidence with school aged children of 25 to 40 per cent.[31,50] Chewable tablets of 1.0 mg sodium fluoride used daily are similarly effective.[29,41] Custom made mouthguards used with 0.6 per cent APF gels offer an additional alternative,[22,23] and are recommended in cases where caries is extremely active, as discussed by Loesche and Wei and Wefel in their accompanying papers in this symposium.

Teen-Age and Adults

Continued use of fluoride supplements for all patients with active caries is recommended to aid in controlling the disease. Chewable tablets of 1.0 mg sodium fluoride are convenient for daily use. Mouthrinses formulated for a topical fluoride benefit and fresh oral sensation are also useful. Preparations containing 0.05 per cent sodium fluoride in a combination with surface active ingredients and pleasant flavors can be used as many times daily as desired. Expectoration is necessary as with most oral rinses for adults due to the surface active components which could disturb the gastrointestinal tract.

Table 2. Sample Prescriptions for Therapeutic Fluorides.

Daily Dietary Supplement of Fluoride (Liquid)	
Rx	Sodium fluoride 0.26 gm in distilled water to make 60 ml
Disp.	In a plastic dropper bottle that delivers 20 drops per each ml
Sig.	Place * drops on tongue or inside cheek daily
	* 10 drops delivers 2.2 mg sodium fluoride (1.0 mg F)
Fluoride Tablets: Combined Systemic and Topical Use	
Rx	Sodium fluoride chewable tablets, 2.2 mg NaF (1.0 mg F)
Disp.	120 tablets
Sig.	One tablet, chewed and swished daily after brushing and flossing at bedtime.
Fluoride Mouthrinse	
Rx	Sodium fluoride 0.05% liquid
Disp.	400 ml
Sig.	Rinse mouth with one teaspoonful (5 ml) for one minute daily after brushing and flossing, then swallow/do not swallow.*
	* depending on systemic fluoride intake.

SPECIAL CONDITIONS

Xerostomia, especially following extensive radiation therapy, and exposed cementum are adult conditions which contribute to an increased incidence of dental caries. When extensive caries occur in adults an intensive topical fluoride treatment is advised. The use of 0.6 per cent fluoride gels in custom fitted trays for at least 4 minutes daily has been found to control the caries process.[13,18] This treatment has been effective enough to raise questions about the routine extraction of teeth in the radiation field.

The use of a higher potency fluoride and high frequency approach to application has been found maximally effective. Kits containing the gel and a tray which can be formed to fit an individual are available.

SUMMARY

Fluoride supplements prescribed as recommended have been shown to be an effective and safe measure in the control of dental caries. Table 2 illustrates several sample prescriptions. Knowledge of the water supply ingested regularly as well as the age of the patient is necessary to properly prescribe fluoride supplements.

The vehicle selected to provide the recommended dosage at the desired frequency is best chosen in consultation with the parents or guardian. Age is a special factor when children are too young to manage chewable tablets or rinses or after the crowns of the teeth are fully formed. Changing from one form of fluoride supplement to another may increase patient motivation. Therefore a program which varies as the patient reaches different ages is encouraged.

Mottled enamel is being seen in patients who have received 0.5 mg of fluoride since birth. Initiation of fluoride supplements is recommended at 6 months of age in fluoride deficient communities. For patients in suboptimally fluoridated communities (0.3–0.7 ppm) reference to the dosages suggested in Table 1 is

advised. The topical benefits of fluoride supplements are appreciable, and there are additive benefits for those with high caries experience in fluoridated communities. Expectoration of fluoride supplements after thorough oral irrigation for patients in fluoridated areas who are still forming crowns of teeth is a satisfactory method of administration. Ingestion of 1.0 mg fluoride doses is believed to be safe and suitable for older patients in fluoridated areas with caries problems.

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The Swine Flu Program

Some Thoughts for Preventive Dentistry

H. Barry Waldman, D.D.S., Ph.D., M.P.H.*

After much procrastination and some occasional "proper public health thoughts"—not to mention some prodding from my wife–I received my swine flu vaccination last month. Swept up in the national program by a blizzard of advertisement, millions of men and women were coaxed to roll up their sleeves and await the inevitable "ouch" in the belief that they would be saved from the annoyance that they had experienced in the periodic and relatively mild flu epidemics of the past decade or two. Some even believed that they would be spared the dreaded horrors of the post World War I influenza pandemic.

By the end of December 1976, between the rumors of related deaths and paralysis of those who had received shots, or who were in contact with those who had been immunized, the public program was ended. Little possibility exists that the program will be reinstituted, whether the supposed relation to the mass swine flu immunizations is disproved or not.

Whether an epidemic has been prevented, or might never have occurred had millions of dollars and untold hours of work by tens of thousands of volunteers and paid workers not been expended, may never be known. In either event, irrevocable damage has been done to the cause of preventive health care. The public seems to take for granted their current state of health as a result of the gradual passage of many of the communicable diseases of past centuries. Polio, diptheria, small pox, and other immunization levels in the population have fallen dangerously low. The swine flu episode can not but reinforce this indifference!

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We seem to have a penchant to blunt the hard won advances in health care services by a seemingly endless array of events. Whether it was the Senator Eagleton event during the 1972 national election and its reverberations on mental health programs, the excess radiation scares in mammography screenings, the politicalization of programs to institute fluoridation of community water supplies, or diethylstilbestrol usage to prevent miscarriages which ironically may produce cancer in these same children, we seem to go out of our way to convince the public that the scientific community and the health care practitioners are suspect, if not down right dangerous. If that weren't enough, Ivan Illich's best seller, "Medical Nemesis," adds fuel to the fire with the thought that medical practice has passed from the era of bleeding, purging and enemas to the modern period of "iatrogenesis" or doctor-caused diseases. Is it any wonder that in this environment the dental profession's programs for prevention are experiencing limited successes?

It seems almost ludicrous to discuss preventive dentistry at a time of major concern over the immunization levels for life threatening communicable diseases. Yet, as dentists, it is essential for us to take part in general health preventive programs, while monitoring their relation to our particular areas of expertise. How successful can we expect to be in dental programs when the general public is indifferent to the general cloud of cigarette smoke that envelopes their lives, or is unable to buckle up in automobiles because they may crease their clothing, limit movement, or whatever other excuse is used.

It is not uncommon to read about the difficulties of establishing programs for preventive dentistry in an environment where patients generally are not attuned to delayed forms of negative gratification; *e.g.*, if you don't smoke, you may not get lung cancer in 30 years. This usual orientation is concerned with the general health attitudes and how they affect dentistry. My concern is the effect that preventive dentistry, or lack of results of such programs, may have on general health preventive programs. In other words, is the dental profession, with its much publicized programs in preventive care, destined to reinforce the public's recalcitrance to general health preventive measures?

Consider for a moment how many dental patients do not follow the prescribed dietary regimen, dental floss acrobatics, tooth brush contortions, and the other sacred formulas of preventive care. No doubt the practitioner's first response is that the fault lies with the patients, since they had been involved in repeated educational sessions offered by dental hygienists and assistants in specially designed preventive dentistry programs.

Whether it is the patient's lack of determination or some fault in the dental office procedures, the results are the same—more decay, higher plaque scores, deepened gingival pockets, and increased dental bills. That's right, preventive care doesn't work; at least from the patient's point of view. Yes, we know they haven't carried out the prescribed home care routine, despite the many hours of effort spent in preventive dentistry programming. But while the dentist and his staff are aware that, for the most part, the patient is probably at fault, from the patient's perspective, he at least has attempted to improve and expects significant return on his investment of time and money.

In an analogous situation, every dentist has had experience with an angered parent who rebels when informed that their child has several

more cavities; despite the fact that a topical fluoride treatment had been carried out 6 months before the current check-up. All of the dentist's pronouncements about the "average reduction of decay for a general population" are meaningless. Their child has more cavities which should have been prevented with their last financial investment for dental care.

As dentists, our work is particularly vulnerable to the breakdown of preventive care, because we rely so heavily upon daily home care by patients. Whereas our medical colleagues can impart permanent immunity from certain diseases with a single injection or swallow of medication, the efforts at preventive dentistry are lifelong and are all too often beyond the control of the practitioner. Yes, there are all too many general health problems which are beyond the capabilities of the physician, but as dentists, the permanency of virtually our entire service rests upon the whims of our patients—many of whom are children.

There have been some reports on advances in experimental programs to prevent dental disease by various forms of inoculation. However, for the present, with the exception of community water fluoridation programs and to some extent sealants, preventive dentistry relies for the most part on the patient's continual interest and participation.

True, some practitioners have been particularly successful in motivating their patients. But many more have been unable to demonstrate long-term patient adherence to a preventive dental disease regimen. If we are aware of this fact and yet persist in our education sessions on prevention, as though they are some new found panacea for all the woes of dental disease, are we not contributing to the general disillusionment with preventive care? This is not to say that we should disregard our efforts to modify patients' habits and return to our profession's traditional role of reparative health practitioners. On the contrary, our efforts to transform our profession to one with a preventive orientation is to be commended and supported. We must, however, temper our new found zeal for prevention with the reality of patient non- or semi-compliance.

It seems almost a paradox to argue that by advocating prevention to our individual patients we somehow may be the cause for increased resistance to programs for prevention. But we are in a particularly vulnerable position because of our complete reliance on patient cooperation. No matter how effective are our technical feats, they reside on the quicksand of patient indifference, motivations, and a whole host of imponderable psychological characteristics. In addition, there are the tens of millions in our country who, because of economic, social, psychologic, and a whole host of other reasons, do not receive on-going dental health services and, therefore, are unreached by our much publicized individualized preventive programs.

Given such a dilemma, the swine flu program may provide at least some valuable lessons for our profession's future efforts. For example: 1) don't promise results which can't be proven or delivered; 2) don't guarantee that there is some sure-fire approach to provide care for *everyone*; 3) most people probably will not respond to preventive measures even if there are no economic costs involved; 4) always consider the long-term consequences of the failure of a program before it is instituted (remember Murphy's Law, if something can go wrong, it will!); 5) preventive programs which require patient-initiated actions are subject to a high rate of failure.

One hardly can expect the president to step before the television cameras, as he did in the swine flu episode, and announce a mass prevention program in the name of dental disease. Such programs long will remain within the domain of the individual private practitioner and public health centers. The champions of the swine flu program adamantly proclaimed that each and every American would receive the necessary vaccine, and therein sacrificed the cause of preventive medicine to some political end. With moderation, the outcome of our efforts to prevent dental disease can be more successful. However, we first must acknowledge the all too often reality of patient indifference and fatalism in relation to dental disease; and thereby advance beyond the utopian attitude that dental disease can be conquered "if only the patient would cooperate."

We may have been sold by our own programming efforts and have lost sight of the need to move beyond patient-initiated prevention programs. If we do not tone down our virtual religious ardour of these efforts, the dental profession is in the similar position as the swine flu program zealots. We will be destined to reinforce the public's disenchantment with general health preventive programs.

Subject Index to Volume 4

A

Ankylosis, tooth eruption and, 4:5:39
Antibacterial agent, topical fluorides as, 4:1:21
Arch length, 4:5:31
Automatic film processing, 4:6:18

B

Baseline gingivitis scores, reduction with repeated prophylaxes, 4:6:28

C

Cancer, head and neck, early detection using oral/facial self-examination, 4:5:47
Caries Prevention, by electroless deposition of metals, 4:1:37
Child behavior problems, prevention in the dental office, 4:2:23

D

Dental Film Processor, automatic, care and maintenance of, 4:6:20
Dental plaque, effect of urea peroxide solution on, 4:6:25
Dental practice, topical fluorides in, 4:4:25
Dental radiography, factors that influence quality, 4:6:8
Dental radiography, with the versatile intraoral positioner system, 4:3:14
Dental radiology, rare earth imaging in, 4:3:7

F

Fluoride, enamel, its anti-caries effects, 4:1:8
Fluoride rinsing, 4:5:25
Fluorides, topical, as an antibacterial agent, 4:1:21
in dental practice, 4:4:25
Fluoride supplements, for infants and preschool children, 4:3:28

G

Gingival health, psychological and chemical mediators of, 4:4:6

H

Health, gingival, psychological and chemical mediators of, 4:4:6

L

Lesions, proximal surface carious, histologic-radiographic relation of, 4:6:23

M

Malignant disease, role of dentistry in treatment, 4:1:28
Mediators, psychological and chemical, of gingival health, 4:4:6
Microleakage, prevention, and achievement of optimal marginal adaptation, 4:2:16

O

Orthodontics, preventive and interceptive, 4:5:7

P

Papillary bleeding index, patient motivation with, 4:4:20
Patient motivation, with the papillary bleeding index, 4:4:20
Prophylaxis, repeated, reduction of baseline gingivitis scores with, 4:6:28

R

Rare earth imaging, in dental radiology, 4:3:7

S

Self-examination, oral/facial, early detection of head and neck cancer using, 4:5:47
Sugar-substitutes, in preventive cariology, 4:2:8
Swine flu program, related to preventive dentistry, 4:6:37

T

Tooth eruption, and ankylosis, 4:5:39

U

Urea peroxide solution, effect on dental plaque, 4:6:25

V

Versatile intraoral positioner system, dental radiography with, 4:3:14

Authors Index to Volume 4

B

Braham, R.L., 4:1:28
Buchholz, R.E., 4:6:23

C

Chilton, N.W., 4:6:28
Crabtree, C. L., 4:6:8
Cutright, D.E., 4:1:37

E

Eichenbaum, I.W., 4:5:39
Elsasser, Ch., 4:4:20

F

Fortier, A.P., 4:6:20
Freeman, J.D., 4:5:7
Freedman, M.L., 4:3:7

G

Grabau, J.C., 4:5:47

H

Hoffman, J.I., 4:1:37
Hummel, E., 4:3:7

I

Imfeld, Th., 4:2:8

K

Kirchhof, S., 4:3:7
Korf, S.R., 4:2:23

L

Leske, G.S., 4:5:25
Loesche, W.J., 4:1:21
Lowey, W.G., 4:5:25
Lüescher, B., 4:2:16

M

Malerman, A.J., 4:5:31
Mandel, I.D., 4:6:28
McDermott, T., 4:2:16
Mellberg, J.R., 4:1:8
Manhold, E.A., 4:6:25
Manhold, J. H., 4:6:25
Mühlemann, H.R., 4:2:6,8,16,4:5,6

O

O'Keefe, T.J., 4:1:37

P

Parkins, F.M., 4:1:5, 4:3:28, 4:6:30

R

Reiskin, A.B., 4:3:7
Richards, A.G., 4:3:6
Ripa, L.W., 4:5:25

S

Saxer, U.P., 4:4:20
Scott, S.J., 4:5:47

T

Talbott, K., 4:6:28
Thunthy, K.H., 4:6:18
Turconi, B., 4:4:20

U

Updegrave, W.J., 4:3:14

W

Waldman, H.B., 4:6:37
Wefel, J.S., 4:3:28, 4:25
Wei, S.H. 4:3:28, 4:25
Woody, R.D., 4:1:37

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